

Chapter 2

DESCRIPTION OF THE WATER BODY

INTRODUCTION

The Loxahatchee River and Estuary and its upstream watershed are located along the Lower East Coast of Florida within the LEC Planning area. This watershed drains an area of approximately 200 square miles, is located within northern Palm Beach and southern Martin Counties and connects to the Atlantic Ocean via the Jupiter Inlet, in Jupiter, Florida. The Loxahatchee River central embayment is at the confluence of three major tributaries: the Northwest Fork, the North Fork and the Southwest Fork. The Northwest Fork originates in the Loxahatchee Slough, flows north and bends east through Jonathan Dickinson State Park, and then flows southeast towards the Jupiter Inlet (**Figure 2**). The Atlantic Coastal Ridge in Eastern Martin County forms the headwaters of the North Fork, which flows south-southeast into the Loxahatchee River Estuary. All but one mile of the Southwest Fork has been channelized to form the C-18 canal which flows northeast through Palm Beach County.



Figure 2. Locations of Major Features in the Loxahatchee River Watershed

The Loxahatchee River and upstream floodplain are unique regional resources in several ways. The river has often been referred to as the “last free flowing river in southeast Florida”. In May 1985, 7.5 miles the Northwest Fork of the Loxahatchee River was federally designated as Florida's first Wild and Scenic River. In addition, different portions of the River and estuary are also designated as an Aquatic Preserve, Outstanding Florida Waters and a State Park. The Northwest Fork also represents one of the last vestiges of native cypress river-swamp within southeast Florida. In addition, large sections of the river's watershed, and river corridor are included within Jonathan Dickinson State Park which contains an outstanding example of the region's natural habitats.

The watershed is also unique in that it contains a number of natural areas that are essentially intact and in public ownership. These areas include the J.W. Corbett Wildlife Management Area, Jonathan Dickinson State Park, Beeline Natural Areas, Hobe Sound National Wildlife Refuge, Juno Hills Natural Area, Jupiter Ridge Natural Area, Pal-Mar, and the Atlantic Coastal ridge. These natural areas contain pinelands, sand pine scrub, xeric oak scrub, hardwood hammock, freshwater marsh, wet prairie, cypress swamp, mangrove swamps, ponds, sloughs, river and streams, seagrass and oyster beds, and coastal dunes. These areas support diverse biological communities, including many designated species (FDEP, 1998).

Preservation and enhancement of the outstanding natural and cultural values of Florida's only federally designated Wild and Scenic River are the primary goals of the SFWMD's management program for this area. The District's vision for protecting the water resources of the river include: 1) maintaining surface water and groundwater flows to the Northwest Fork, 2) providing minimum flows to control upstream movement of the saltwater wedge during dry conditions, 3) maintaining existing water quality in the River by eliminating identified water quality problems when possible, and 4) providing freshwater flows needed to sustain natural systems within the downstream river and estuary.

DESCRIPTION OF THE WATERSHED

Climate, Rainfall and Seasonal Weather Patterns

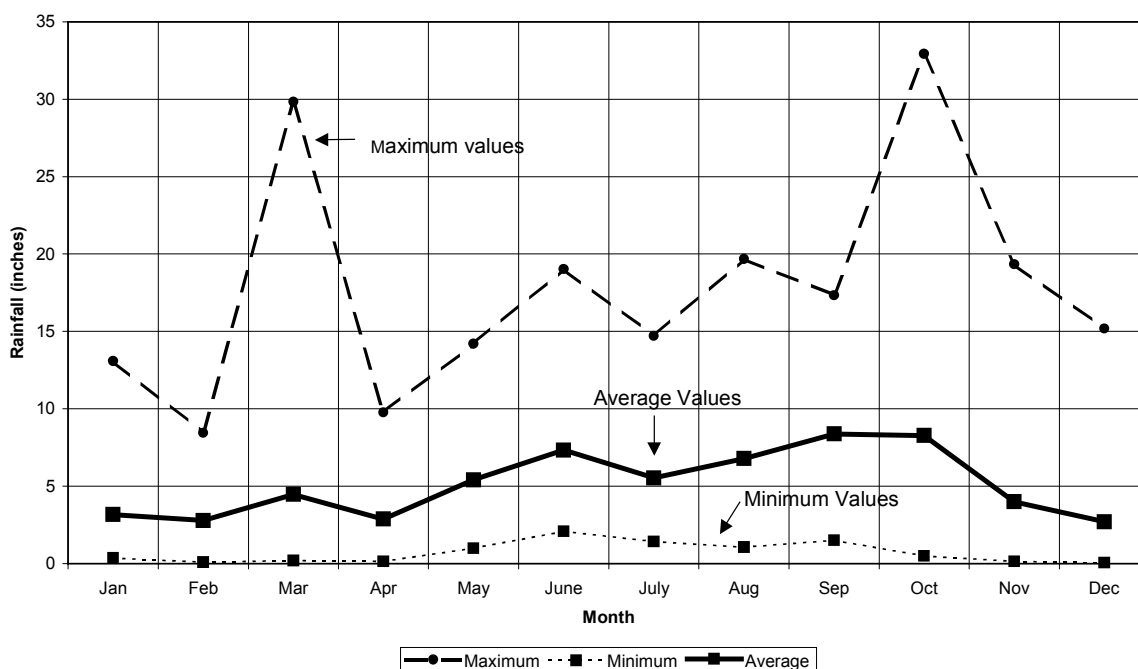
The climate is subtropical with average daily temperatures ranging from an average of 82° F in summer to an average of approximately 66° F in winter. Winters are mild with warm days and moderately cool nights. August is the warmest month, usually having more than 29 days with temperatures above 90 degrees. Even in the coldest winters, temperatures at or below freezing are rare. The average annual temperature is 75° F (Breedlove, 1982).

Prevailing winds are east/southeast, providing a marine influence, with an average velocity of approximately 10 miles per hour. Air in the study area is moist and unstable. These characteristics lead to frequent rain showers, usually of short duration. During the summer months, thundershowers occur on average, every other day.

Rainfall within the Loxahatchee River watershed averages about 61 inches annually (Breedlove, 1982) with heaviest precipitation occurring during the wet season. Based on average monthly precipitation a “wet” and “dry” season can be established. For the period of record 1900-1995, the majority of rainfall (67%) occurs from May through October (**Figure 3**). In contrast, only 33% of this total falls during the dry season (November-April). On average, the highest rainfall occurs during the months of September and October (8.3-8.4 inches/month) while minimum average values range between 2.7 and 2.8 inches/month for the months of December, February and April (**Figure 3**). During the winter and early spring there are some years in which there are long periods of time in which there is little or no rainfall, resulting in a regional drought condition (e.g. 1971, 1981, 1989/90). In contrast, tropical storms or hurricanes over the area can produce as much as 6 to 10 inches of rainfall in one day. Total annual rainfall can be as much as 110 inches or as low as 39 inches.

Evapotranspiration (ET) is the sum of evaporation and transpiration. Like rainfall, ET is generally expressed in terms of inches of water per year. For the South Florida Area, approximately 45 inches of water per year is returned to the atmosphere by evapotranspiration. The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average ground water recharge.

Figure 3. Average, Minimum and Maximum Rainfall by Month for the Jupiter Area (1900-1990)



Major Drainage Basins

The major feature of the watershed is the Loxahatchee River, which historically drained over 250 sq. miles of inland sloughs and wetlands. Some of the major tributary streams such as the North Fork, the Northwest Fork and Kitching Creek exist today much within their historic banks. Other creeks such as the Southwest Fork, Limestone Creek, and parts of Cypress Creek, have been greatly altered. Today the watershed encompasses 80 percent of its historic size (approximately 200 sq. miles). More than half of the land in these basins remains undeveloped and the remainder has been altered by agricultural or urban development. Undeveloped lands consist of wetlands and uplands. The watershed also contains about 4000 acres of open water including lakes and the estuary (FDEP 1998).

Although the total area of the drainage basin has not have changed dramatically, drainage patterns within the basin have been significantly altered due to road construction (e.g., Beeline highway and Florida Turnpike), construction of the C-18 Canal and associated water control structures, and development of an extensive secondary drainage network designed primarily to provide flood protection for agricultural and urban development. A significant amount of water is used within the basin for potable use and irrigation (**Tables 6 and 7**). Drainage and development within the basin has lowered groundwater levels and altered natural flow regimes and drainage patterns.

The watershed contains seven drainage basins, varying in size from seventeen to one hundred square miles, which provides runoff to the three forks of the Loxahatchee River (**Figure 4**). The subbasin boundaries were based primarily on hydrology and secondarily on land use. Each of these subbasins is unique and plays an important role in the watershed.

Subbasin1: Jonathan Dickinson. The northeastern portion of the Loxahatchee River watershed actually consists of two parallel basins, the North Fork of the Loxahatchee and Kitching Creek. Over 40% of the 36 square miles of this subbasin are within the boundaries of Jonathan Dickinson State Park, and contribute natural runoff.

Subbasin 2: Coastal. This subbasin consists of approximately 34 square miles of land that drains to the ICW and out the Jupiter Inlet. The coastal subbasin has been developed for maximum urban residential, commercial, and recreational use. Very few small and isolated natural areas remain.

Subbasin 3: Estuary. This central drainage subbasin is highly developed with urban land uses and contributes significant runoff to the major embayment of the Loxahatchee River. Consisting of over 21 square miles of the watershed, this subbasin provides aquatic recreational opportunities that sometimes exceed the river's carrying capacity on weekends and holidays.

Subbasin 4: C-18 Canal/Corbett WMA. Over 100 square miles make this the largest subbasin in the watershed. Much of the land in this subbasin, comprising the southwestern portion of the watershed, is publicly owned and protected. This subbasin includes the remnants of the Hungryland and Loxahatchee Sloughs, which historically fed the Northwest Fork of the

Loxahatchee River. At one time, the Loxahatchee Slough extended south into what is now known as the West Palm Beach Water Catchment Area, the source of drinking water for the City of West Palm Beach.

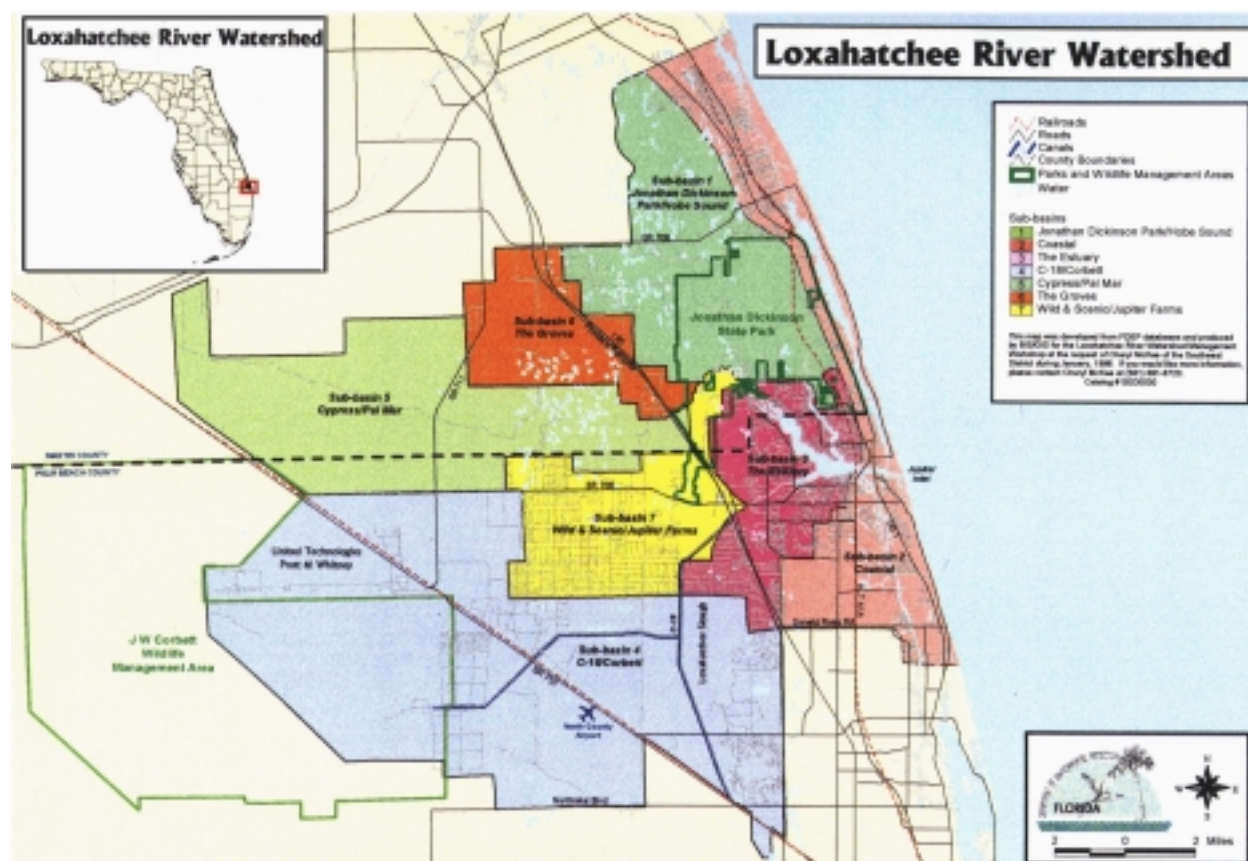


Figure 4. Subbasins of the Loxahatchee River watershed (from FDEP, 1998).

Subbasin 5: Cypress Creek/Pal-Mar. Cypress Creek, a large 46 square mile subbasin, drains a sizable wetland located in the western extremities of the watershed and is one of the major tributaries to the Loxahatchee River. Most of these wetlands remain intact, however the eastern flow ways leading to the creek have been disturbed by rural development.

Subbasin 6: Groves. While agricultural operations are found in four of the seven subbasins, the predominant land use in this 17 sq. mile subbasin is agriculture, primarily citrus. Although the hydrology in this subbasin has been altered to support agriculture, wildlife utilization is good and the land provides a valuable greenway link between large natural areas within the watershed.

Subbasin 7: Wild & Scenic River/Jupiter Farms. This subbasin is over 23 sq. mi. and is divided into a larger upstream section which has been channelized and now supports substantial rural development, and the downstream portion that comprise the “wild and scenic” Northwest Fork of the Loxahatchee River (Figure 4). Water quality in the Northwest Fork is one of the chief concerns in this subbasin (FDEP, 1998).

Watershed Components

The Loxahatchee River and Estuary system can be divided into three components that affect, or are affected by the need to establish Minimum Flows and Levels (MFLs). These include:

- The River itself (especially the Northwest Fork and its “Wild and Scenic River” corridor) and its upstream watershed which includes the Loxahatchee Slough, Jonathan Dickinson State Park, Cypress Creek, Hobe Grove Ditch, and Kitching Creek
- The River and downstream estuary which includes the Southwest Fork, North Fork and central embayment area
- Adjacent coastal waters of the Intracoastal waterway, Lake Worth Creek and Jupiter Inlet

Loxahatchee River and Upstream Watershed

Northwest Fork (Wild & Scenic River)

The Northwest Fork of the River has three major tributaries -- **Cypress Creek** that drains Jupiter Farms, Ranch Colony, Hungryland Slough, and Pal Mar; **Hobe Grove Ditch**, which drains Federation Canal, and **Kitching Creek**, Jenkins Ditch, and Wilson Creek that drain wetlands north of the river. (**Figure 5**).

The Northwest Fork is a natural river channel. Maximum depths of 10 to 29 feet extend upstream near Cypress Creek. Farther upstream, maximum depths are generally less than 10 feet. The Northwest Fork represents a last vestige of the native cypress river-swamp within southeast Florida (USDOI/NPS 1982). The cypress swamp community extends 4 miles down the Northwest Fork of the river from Indiantown Road. Originally extending further downstream to near river mile 5.5 (McPherson unpublished data). Today, freshwater cypress and hardwood communities share the floodplain with saltwater tolerant mangroves from river mile 8.6 to river mile 10 (**see Appendix B**) as result of saltwater intrusion. The remaining cypress swamp community along this stretch of the river exhibits high species diversity due to the overlap of tropical and temperate zone communities. Tropical vegetation such as wild coffee, myrsine, leather fern, and cocoplum may be found along with pop ash, water hickory, red bay, royal fern and buttonbush, which are considered to be examples of more northern flora. (USDOI/NPS 1982).

The slightly elevated areas that border the NW Fork of the river are dominated by slash pine and saw palmetto. Also common are areas of dwarfed and gnarled scrub oak, and many herbs and grasses. In May 1985, a 7.5-mile, pristine portion of the upper Northwest Fork was designated by the U.S. Department of the Interior for inclusion in the Federal Wild and Scenic Rivers Program.

The main stem of the Loxahatchee River originates in the Loxahatchee Slough, a pristine cypress swamp and wet prairie wetland located southwest of the river (**Figure 5**). Outflow from the Loxahatchee Slough travels downstream through the G-92 structure and C-14 Canal to the

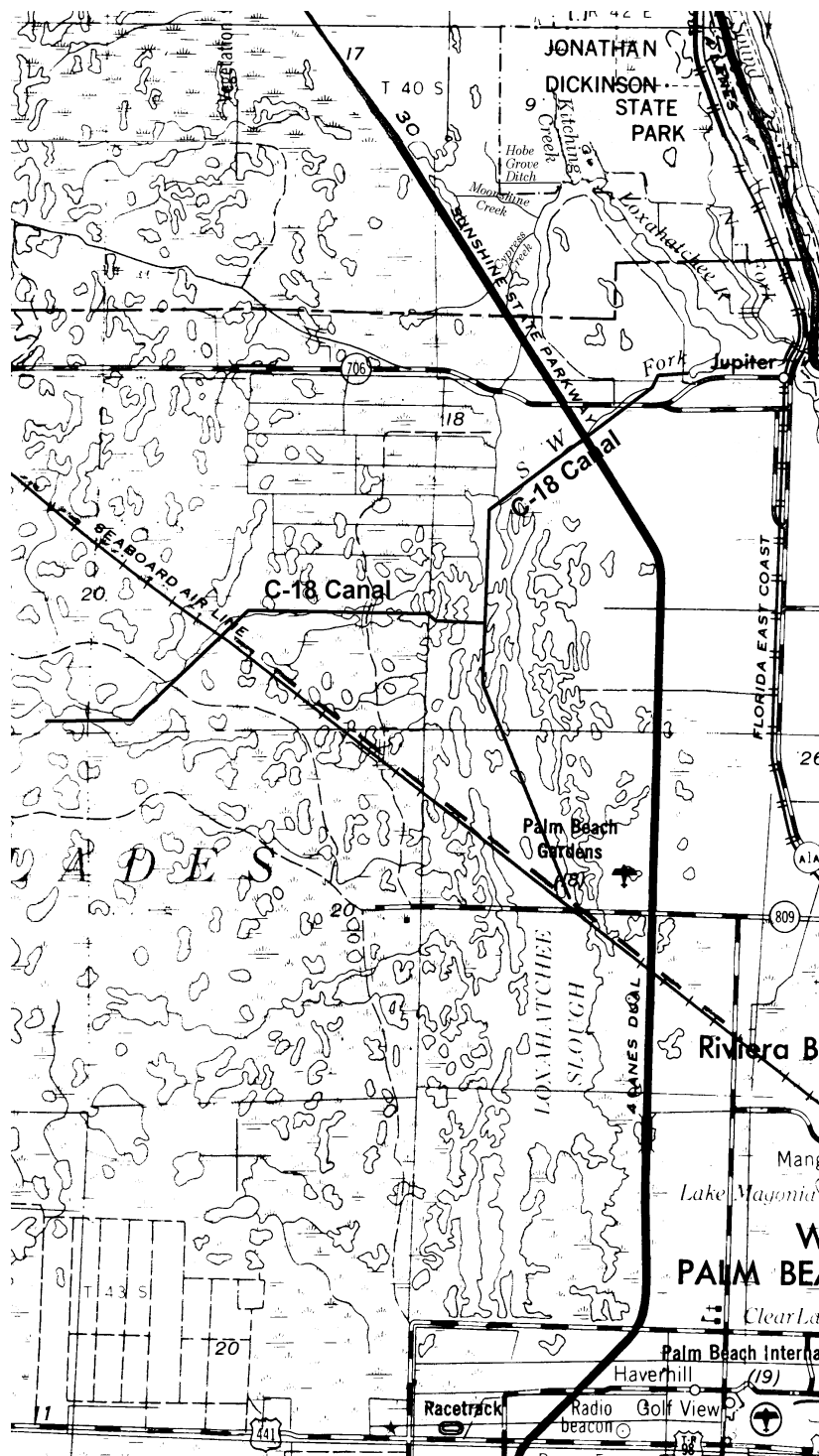


Figure 5. Major Features of the Loxahatchee River and upstream watershed System.

Northwest Fork of the river. Water passes through cypress swamp, mangrove forest, historical and archeological sites, and Jonathan Dickinson State Park to the saline waters of the estuary. The floodplain of the NW Fork of the river is a prime example of a pristine subtropical riverine cypress swamp. The management goal for this system as identified in the *Loxahatchee River*

National Wild and Scenic River Management Plan (FDEP/SFWMD 2000), is to preserve historic communities and functions, especially the bald cypress community, which includes a number of trees 300-400 years old. Threats to floodplain vegetation include periods of saltwater intrusion within upstream areas of the river, which result in death or stress to the remaining river-cypress swamp community and subsequent replacement by saltwater tolerant red mangrove species. Much of the watershed remains in a natural (undeveloped) state or in low-intensity agricultural use so that the quality of runoff water from most areas is good. Large tracts are protected in parks or preserves and additional land is being purchased by various private interests and government entities for preservation.

The NW Fork of the Loxahatchee River has been designated as a Wild and Scenic River by the State of Florida and the federal government. Special consideration should be given to ensure that the watershed surrounding this portion of the river is protected to maintain natural flow conditions, good water quality and high quality natural areas. The downstream estuary is part of the Loxahatchee River-Lake Worth Creek Aquatic Preserve.

North Fork

The North Fork of the river (Figure 2) is a very shallow tributary and currently provides only a small percentage of the total freshwater flow to the estuary (Russell and McPherson 1984; Sonntag and McPherson 1984). Estuarine conditions extend approximately 5.0 miles up this branch from the mouth of the Inlet (McPherson and Sabanskas 1980). Oyster reefs are rare, and during a 1990 survey, seagrasses grew as a narrow and thinning strip along both banks of the North Fork, to the Tequesta Drive bridge (Law Environmental, 1991).

Southwest Fork

The Southwest Fork (**Figure 2**) has been heavily altered, dredged and channelized (McPherson *et al.* 1982). The Southwest Fork includes the C-18 Canal, which is a Class I water body. Water flows from the canal through the water control structure at S-46 into the Southwest Fork of the Loxahatchee Estuary, which is also part of the Aquatic Preserve.

Freshwater discharges to the Southwest Fork, with the exception of a couple of small creeks, are controlled by S-46, an automated structure providing overflow from Canal C-18. Salinity in the Southwest Fork is influenced primarily by the S-46 structure and discharges from C-18 (FDEP, 1998). In the Southwest Fork, oyster reefs occur downstream of Loxahatchee River Road, to Bullock Point. During a 1990 survey, no seagrass beds were found upstream of the mouth of the Southwest Fork (Law Environmental, 1991).

The Loxahatchee Estuary

The Loxahatchee River Estuary has an average depth of about 4 feet. Estuarine conditions extend from the Jupiter Inlet to about 5 miles up the Southwest Fork, 6 miles up the North Fork, and 10 miles up the Northwest Fork. Sandbars and oyster bars in the central embayment of the

estuary are occasionally exposed at low tide. Some of the deeper areas present within the estuary are a result of past dredging activities.

Historical evidence indicates the estuary and its connection to the Atlantic Ocean periodically closed and opened as a result of natural causes. Originally the estuary received flow not only from the Loxahatchee River, but also from Lake Worth Creek and Jupiter Sound. These flows helped keep the inlet open. Near the turn of the century, some of this flow was diverted by construction of the Intracoastal Waterway, the Lake Worth inlet and St. Lucie Inlet. Consequently, the Jupiter Inlet remained closed much of the time until 1947 when it was permanently opened by dredging (Russell and McPherson 1984).

The central embayment (**Figure 2**) is dominated by tidal changes. Freshwater flows from contributing drainage basins have been altered, resulting in salinity changes within the upstream river forks. Physical changes in the estuary such as permanent opening of the Jupiter Inlet, dredging of main channels, expansion and contraction of the opening at the Florida East Coast Railroad trestle, and water control structure management have influenced salinity regimes in the estuary (Law Environmental 1991).

The estuary contains seagrass beds, oyster bars, and mangroves. The Atlantic Intracoastal Waterway, Lake Worth Creek and Jupiter Inlet are major associated navigational features. Dubois Creek and Park and Jupiter Inlet Park are regionally important recreational areas within the estuarine portion of the watershed. The Loxahatchee-Lake Worth Creek Aquatic Preserve includes protected habitat for native aquatic plants and animals and associated wildlife. The estuary also contains substantial areas of emergent shoreline plant communities - such as mangroves and *Spartina* and many submerged bars covered with seagrasses and other submerged aquatic vegetation. The relative distribution and abundance of these plants have changed over time in response to changes in water quality, currents, substrate conditions and salinity.

Shoal grass (*Halodule wrightii*) is the dominant seagrass species found within the estuary. Other seagrass species observed included: star grass (*Halophila* sp.), turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and more recently, Johnson's seagrass (*Halophila johnsonii*) (Law Environmental 1991; Kenworthy, 1992).

The Loxahatchee River watershed provides habitat for a wide variety of animals including several threatened and endangered species. The river supports a complex community of freshwater and brackish water fishes. These in turn are dependent upon a proper balance among the phytoplankton, zooplankton and benthic macroinvertebrate communities (including oysters and clams, shrimp, snails and other estuarine species) that provide food for fishes and are important components of the river and estuary ecosystems. Development of minimum flow criteria should consider salinity conditions that are needed not only for *survival* of adult plants and animals, but also for spawning and recruitment of early life stages, and to protect these organisms from an imbalance in predators and parasites.

Adjacent Coastal Waters

The Coastal Subbasin encompasses approximately 34 square miles and stretches from Hobe Sound south to Juno Beach, a distance of 20 miles (**Figure 2**). This area includes the Jupiter Inlet and adjacent offshore waters and the Intracoastal Waterway (ICW), which is also known as the Indian River Lagoon (or Hobe Sound) north of the Jupiter Inlet and Lake Worth Creek south of the Jupiter Inlet. The movement of water in this sub-basin is predominantly influenced by tides, with lesser impacts from wind and drainage of upland areas. On incoming tides, most of the seawater enters the inlet and moves westward into the estuary and northward into the Indian River section of the ICW. A substantially smaller interface is created between the incoming tides and the portion of Lake Worth Creek between the inlet and Juno Beach. Under normal conditions, water is discharged out the inlet from the estuary and its three tributaries on an ebb tide.

Lands adjacent to these areas include both developed land and natural landscapes. A major defining characteristic of the Coastal Sub-basin is the Atlantic Coastal Ridge. Water drains quickly in the area due to the fine sands. Stormwater can have an impact on the area by leaching fertilizer and pesticide to the groundwater. Groundwater beneath much of the Coastal Sub-basin consists of deep saline areas overlain by thin freshwater lenses. The volume of freshwater available for withdrawal is very limited.

The urbanized corridor of U.S. Highway 1 is a major feature of the watershed in Palm Beach and Martin counties. Stormwater contributions come from a number of developments. Some have canal systems open to the ICW, others pipe runoff into the surface waters. Publicly-held conservation lands are located at both ends of the sub-basin, in Juno Beach and along the Jupiter oceanfront. The watershed includes a small portion of Jonathan Dickinson State Park and a national wildlife refuge south of Hobe Sound.

Hydrologic Alterations of the Watershed

During the past 100 years, the natural hydrologic regime of this watershed has been altered by drainage activities associated with real estate and agricultural development. Time lines of major changes are shown in **Table 1**. Historically the watershed was defined by the natural landforms of the region. Most of the Loxahatchee Basin was drained by the Northwest Fork of the Loxahatchee River. The headwaters of the river originated in the Loxahatchee Marsh and Hungryland Slough. As water levels rose during the rainy season and, owing to Florida's flat topography of the area, freshwater drained off gradually as a shallow sheet flow during the dry season (Breedlove, 1982). Today much of the area has been transected by canals and levees, and the area's water table has been lowered because of these activities. Construction of canals for drainage and flood protection has diverted much of this surface flow to the Southwest Fork of the river (Breedlove, 1982).

The first major event that altered the hydrology of the watershed was the channelization of the Atlantic Intracoastal Waterway between Jacksonville and Miami by the U.S. Army Corps of Engineers (USCOE) between the late 1800s and 1912. The construction of the St Lucie and

Table 1. Loxahatchee River: Time Lines of Change

Colonization/ Homestead Period	<p>3000-750BC - Late Archaic Period: Early Indian encampments along the river</p> <p>750BC-1750AD - East Okeechobee Periods I-IV: Villages and middens constructed near the river</p> <p>1696 - - Jonathan Dickinson is shipwrecked on Jupiter Island</p> <p>1800s - - Seminoles name the river "Lowchow" for turtle and "Hatchee" for River</p> <p>1838 - - Battle of Loxahatchee (January 24, 1838), Second Seminole War</p> <p>1850s - - Loxahatchee River known to locals as Jupiter River</p> <p>1855-1860 - Jupiter Lighthouse constructed</p> <p>1860s - - Early settlers arrive in Martin and Palm Beach County areas</p> <p>1870s - - Ft Jupiter established on Jupiter Island/ Henry Flagler begins to fill in natural slough areas</p> <p>1886 - - The family of Walter Kitching purchases land for \$1.25/acre and establishes trade boat business</p> <p>Late 1800s - 1912 - Atlantic Intracoastal Waterway channelized between Jacksonville and Miami. Construction of St. Lucie and Lake Worth Inlets further diverted flow away from Jupiter Inlet</p>
Drainage Period	<p>Early 1900s -Construction of the Florida East Coast Railroad (FECRR) trestle bridge with filling of surrounding submerged lands</p> <p>1928 - - Small agricultural ditch dredged to divert water from the Loxahatchee Marsh to the Southwest Fork of the Loxahatchee River</p> <p>1930s - - The Lainhart and Masten Dams were privately constructed by local families on the Northwest Fork</p> <p>Mid 1930s-1942 - U.S. Army Corps of Engineers dredged lower estuary</p> <p>1940s - - Bridge Road constructed, sod farms established, reducing sheet flow to northern Kitching Creek</p> <p>1940-41 - Cypress trees were cut for lumber along Kitching Creek</p> <p>1947 - - Jupiter Inlet permanently stabilized for navigation; US. Army Base Camp Murphy deactivated, state acquires property to create Jonathan Dickinson State Park</p> <p>1957-58 - Southwest Fork of the Loxahatchee River heavily altered, dredged and drained by the construction of the C-18 Canal to divert water from the Northwest Fork to the Southwest Fork</p> <p>1968 - - The state acquired land purchased by Trapper Nelson during the 1930s and established his home and grounds as an Interpretive Site</p> <p>1970-71 - Severe drought throughout the watershed further reduced freshwater flows</p> <p>1970 - - Loxahatchee River-Lake Worth Creek Aquatic Preserve established</p> <p>1973 - - USGS publishes <i>The Loxahatchee - A River in Distress</i> (Rodis 1973)</p> <p>1974 - - C-14 Canal allowed water to be re-diverted from C-18 to the Northwest Fork, G-92 Structure constructed at the intersection of C-18 and the Northwest Fork allowing a flow of 50 cfs and a maximum flow of 100 cfs to be redirected to the NW Fork</p> <p>1975 - - Alexander & Crook (1975) document historical migration of mangroves into formerly cypress areas</p> <p>1976-77 - U.S. Army Corps of Engineers dredged the lower estuary, which increased saltwater intrusion</p> <p>1977-78 - Oyster bars dredged at FECRR Bridge to improve navigation and flushing in the embayment area</p> <p>1978 - - Loxahatchee River Environmental Control District began operation of a sewage treatment plant that discharged from 0 to 2.0 million gallons per hour (mg/h) to the Northwest Fork</p>
Urbanization Period	<p>1980s - - Lainhart and Masten Dams were reconstructed to maintain higher water levels</p> <p>1980 - - Operation of S-46 Structure on C-18 Canal altered to provide more storage in the canal. Discharge occurred to the Southwest Fork when water levels were greater than 15 feet above mean sea level</p> <p>1980 - - Three channels were dredged in the embayment area to improve navigation</p> <p>1982 - - In August, Tropical Storm Dennis caused prolonged heavy discharges of freshwater to the estuary</p> <p>1984 - - USGS publish first comprehensive study of surface runoff and salinity distribution within the Loxahatchee River and Estuary (Russell and McPherson 1984)</p> <p>1984 - - Florida Department of Natural Resources reported that the majority of the cypress trees downstream of Kitching Creek (River mile 7.8) were dead</p> <p>1985 - - Pristine portions of the Northwest Fork of the Loxahatchee River designated as a Federal and State Wild and Scenic River</p> <p>1987 - - G-92 is replaced by a gated control structure capable of passing up to 400 cfs via remote telemetry from the SFWMD Operations Control Room</p> <p>2001 - - Projects are underway to restore hydrology in the Loxahatchee Slough and enhance flow to the NW Fork</p>

Lake Worth Inlets further diverted flow away from the Jupiter Inlet, which periodically closed in the vicinity of its present location. Historically, the Jupiter Inlet closed in 1853, 1901, 1910, and 1942 through 1947. It was not permanently stabilized until 1947.

Stabilization of the inlets, increased the flow of saltwater from the Atlantic Ocean into the interior of the watershed. In the early 1900s, saltwater flow was somewhat restricted in the embayment area when the Florida East Coast Railroad (FECRR) trestle bridge was constructed between the Town of Jupiter and the Village of Tequesta. Placement of the bridge required the filling of submerged bottom, which reduced the width of the river, although tidal flow was again increased during the 1930s, 1940s, and 1970's when the Jupiter Inlet District periodically dredged the lower estuary to maintain navigation and obtain fill for low lying areas. In 1977-78, oysters beds along the FECRR Bridge were partially removed to improve navigation and flushing in the embayment area. In 1980, three channels were dug in the central embayment area. Opening up these channels and dredging of the inlets have compounded the salinity encroachment problem (FDEP and SFWMD 2000, Hedgepeth, unpublished).

The geologic history of the Jupiter Inlet and the Loxahatchee River area indicates that oscillations have occurred between a mostly freshwater river system and a tidally influenced estuary (McPherson and Sabanskas 1980; Wanless et al. 1984). When Jupiter Inlet closed or was greatly constricted, upstream salinities ranged from brackish to fresh water. During periods when the inlet was open, salinity increased changing these areas to estuarine or marine conditions impacting freshwater aquatic plant and animal communities as they retreated to upriver areas. This appears to be a key factor that has affected salinities in the downstream river system.

Major changes also occurred within the upstream watershed. The first report of a basin drainage project was in 1928 when a small agricultural ditch was constructed to divert water from the Loxahatchee Marsh to the Southwest Fork of the Loxahatchee River. This project was further expanded in 1957-58 when Canal -18 (C-18) was constructed through natural wetlands to better drain the Loxahatchee Slough after storm events and provide flood protection for new residential development. This alteration reduced the size of the Loxahatchee Basin from 270 to approximately 210 square miles. Now, the C-18 drains over one-half of the Loxahatchee Basin. The freshwater that previously flowed north to the Northwest Fork was diverted to the Southwest Fork where it could be directly discharged to tidal waters through Structure 46 (S-46). Other hydrologic alterations occurred directly on the Northwest Fork and its tributaries. During the 1930s, two local families constructed the Masten and Lainhart Dams on the upper Northwest Fork to slow down the flow of freshwater between Indiantown Road (State Road #706) and Trapper Nelson's settlement. Sometime between 1940 and 1953, Hobe Grove Ditch and the Federation Canal were dredged to drain low-lying areas for citrus groves. Flows to the Northwest Fork via Kitching Creek were further reduced during the 1940's by the construction of Bridge Road (County Road #708) and Jenkin's Ditch and by the introduction of citrus groves and sod farming.

By the 1970's, much of the Loxahatchee Basin had been drained for residential or agricultural uses. The SFWMD placed a culvert (G-92) in C-18 in the early 1970's at the point where the Northwest Fork intersects with C-18 (**Figure 6**).

In response to public concerns that the C-18 diversion was detrimental to the unique fresh-water communities found along the Northwest Fork, this culvert was improved to deliver a sustained flow of 50 cubic feet per second (cfs) and a maximum flow of 100 cfs to the Northwest Fork. Investigations since construction of G-92 indicated that there still remained a salt encroachment problem within the Northwest Fork of the river during dry periods. During the severe drought of 1980-81, the operation of the S-46 Structure was modified to provide storage of water in the canal to recharge local municipal wellfields and reduce the amount of freshwater loss to tide. The structure would discharge to the Southwest Fork only when water levels were greater than 15 feet above mean sea level. In 1987, the capacity of G-92 was increased to allow deliveries of up to 400 cfs.



Figure 6. Location of G-92 Culvert

In order to supplement freshwater flows to the Northwest Fork, the Loxahatchee River District (LRD) began discharging treated sewage to the river in 1978. Between 1978 and 1984 flows averaged from 0 to 2.0 million gallons per hour (mg/h). These flows continued until the wastewater plant discharges were discontinued in the early 1990s, at which time the plant converted to reuse of treated effluent.

Water levels and surface water flows have also been altered within the Loxahatchee and Hungryland Sloughs. An extensive network of regional drainage canals and dikes has been constructed and connected to the C-18 Canal system as it flows north out of the Loxahatchee Slough. The C-14 Canal (C-14), which parallels the C-18 Canal, was constructed by the South Indian River Water Control District to re-divert water from the C-18 Canal back into the Northwest Fork. The C-14 Canal terminates where the river's natural meandering pattern begins about 1/2 mile south of Indiantown Road (SR #706). The C-14 receives inflow from a series of smaller canals and drainage ditches. Construction of Canal C-14 has further restricted the amount of freshwater that can be delivered to the Northwest Fork through G-92 (Russell & McPherson 1984).

Several projects are in the planning stage or underway to restore sheet flow and enhance wetlands in Kitching Creek and Cypress Creek Sub-basins, and the Loxahatchee Slough. Other current projects involve storing and treating runoff in stormwater treatment areas (STAs) for later release to the Northwest Fork during low flow periods.

Major Aquifer Systems

The geologic formations underlying the area of the Loxahatchee River form two aquifers separated by confining beds. The two major aquifers are the shallow, upper 200 feet of sand, (non-artesian) Surficial aquifer and the Floridan aquifer, (over 1,000 feet deep (**Table 2**).

The Surficial Aquifer is composed of permeable Pamlico sand, Anastasia limestone, shell beds, and Caloosahatchee marl. Although the shallow Surficial aquifer represents the primary source of potable water for the watershed, its water bearing qualities vary widely throughout the area. Most of the recharge for the Surficial aquifer is supplied by local rainfall. The bottom of the shallow aquifer is generally about 180 feet below the land surface (Lukasiewicz and Smith, 1996; SFWMD; 1998).

Table 2 . Generalized hydrogeology of the Loxahatchee Watershed

Hydrogeologic System	Hydrogeologic Unit	Aquifer Thickness (Feet)	Water Resource Potential
Surficial Aquifer System	Units not distinct	100-200	Primary source of potable water
Floridan Aquifer System	Upper Hawthorn Confining Zone	500	May only be used for potable drinking water with desalinization.
	Upper Floridan Aquifer		

Source: (Lukasiewicz and Smith, 1996; SFWMD; 1998)

The Floridan Aquifer, is separated from the Surficial by several hundred feet of relatively impermeable clay, and extends to depths of about 1500 feet. This confined aquifer contains water under sufficient pressure to flow to the surface. In the Loxahatchee River area, the aquifer is composed of limestone of the Hawthorn, Tampa, Suwannee, Ocala and Avon Park Formations, ranging in age from 30 to 60 million years. This aquifer is hydrologically isolated from the Surficial Aquifer, and is highly mineralized and contains moderately high salt concentrations. It can be used for potable drinking water supply only with desalinization treatment. The principal recharge area for the Floridan aquifer is located in Polk and Pasco counties in central Florida. These two aquifers supply all of the drinking water for this watershed (FDEP, 1998).

Soils

Soils within Sub-basin 1 (*Jonathan Dickinson/Hobe Sound*) can be divided into two main regions: the Atlantic Coastal Ridge, and the Eastern Flatlands. Old dunes are present near the west side of U.S. Highway 1. Dune ridges and other minor dune patterns run north to south and consist of fine, white sand of the Paola - St. Lucie association. The flatlands contain flat terraces with poorly drained sandy soils that are interspersed with shallow depressions. Soils within Sub-basin 2 (*Coastal*) are generally those associated with Paola-St. Lucie sands and are well-drained with high permeability. In tidal zones, thin muck overlays permeable sands (FDEP, 1998).

Soils within Sub-Basin 3, (*The Estuary*) are divided into three groups. Soils in the northeast are generally well drained sands of the St. Lucie-Urban-Paola association. Well drained sands of the St. Lucie-Urban-Paola association and Pomello and Basinger sands make up the area between the North Fork and the C-18, Southwest Fork drainage Channel. South of the estuary and C-18, Southwest Fork Drainage Channel consists mostly of nearly flat, poorly drained sands of the Wabasso-Riviera soils (FDEP, 1998).

Soils within Sub-Basin 4, (*C-18/Corbett*) are generally of the Riviera sand soil series. Poorly drained sandy soils with a loamy subsoil and in the eastern or "Loxahatchee Slough" area some have a thin layer of muck at the surface. Soils within Sub-Basin 5, (*Cypress/Pal-Mar*) are mostly of the Wabasso, Riviera, and Pineda series: poorly drained and sandy to a depth of 20 to 40 inches (FDEP, 1998).

Soils within Sub-Basin 6, (*The Groves*) are predominantly Hobe fine sand and Nettles sand in the river corridor and immediately west to the groves. The Groves consist mostly of Wabasso-Riviera sands with Pineda-Riviera soils along the northwestern boundary. The western and southwestern areas are predominately Pineda-Riviera-Boca soils. These soils are poorly drained and sandy to a depth of 20 to 40 inches. Soils within Sub-Basin 7, (*Wild and Scenic/Jupiter Farms*) are predominantly poorly drained sandy soils such as those within the Riviera and Wabasso Series and also include Pineda and Oldsman (FDEP, 1998).

Surface Water Hydrology

Water is the most essential component of the Loxahatchee River ecosystem. Clean fresh water of sufficient quantity and appropriate periodicity is essential in maintaining the area's scenic qualities and diverse native plant communities and wildlife populations. Human alterations to the river's natural drainage patterns have reduced the quantity and quality of water in the river, and these changes have contributed to corresponding declines in the river's natural and scenic qualities (FDEP and SFWMD 2000).

In its natural condition, the source of the Loxahatchee River was the Loxahatchee and Hungryland Sloughs located near West Palm Beach. Historically, this area was characterized by swampy flatlands interspersed with small, often interconnected ponds and streams that produced a sheet flow toward the north. Drainage patterns were determined by the poorly defined natural landforms of the area. The major features that presently influence drainage in the river basin are Canal 18 (C-18), the Florida Turnpike, I-95, and State Road 710 (which act as important subbasin divides), and the extensive systems of secondary canals developed by special drainage districts and landowners within the basin (**Figure 7**).

A report prepared by the U.S. Geological Survey (Rodis 1973) concluded that the primary cause of environmental problems facing the river was the upstream movement of salt water. The study attributed changes in the flora and fauna in Jonathan Dickinson State Park and other portions of the river to this cause. Data on salinity and rate of freshwater flow indicated that a minimum continuous flow of 23,000 gallons per minute, or 50 cfs (cubic feet per second) across the Lainhart dam, was required to retard further upstream movement of salt water in the Northwest Fork under the drainage and development conditions that existed at that time.

Much of the reduction in flow observed by the USGS has been attributed to the diversion of historic Northwest Fork flows due to construction of the C-18 canal. The C-18 drainage system is the most prominent feature in the Loxahatchee River basin. The C-18 was constructed in 1958 as part of the Central and South Florida Flood Control Project to improve drainage and flood protection for adjacent agricultural, residential, and industrial land as well as the J.W.

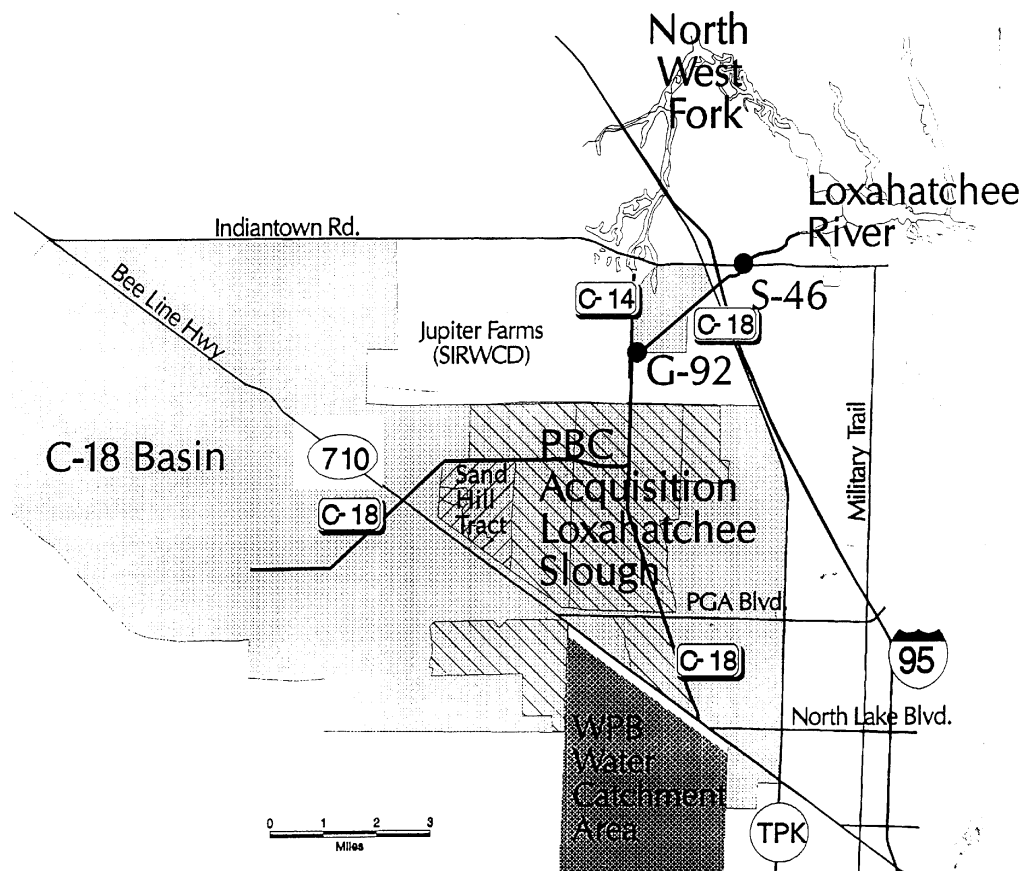


Figure 7. Major features that influence drainage within the river basin (FDEP/SFWMD 2000)

Corbett Wildlife Management Area. This system drains a 106 square-mile area (more than 50 percent of the river basin), and empties into the Southwest Fork through control structure S-46. The C-18 canal is of particular significance because it (a) drained the Loxahatchee Slough, and (b) redirected water that historically flowed from the Slough to the Northwest Fork into the Southwest Fork of the Loxahatchee River. The other major drainage system in the Loxahatchee River basin is maintained by the South Indian River Water Control District (SIRWCD). It lies west of C-18 in an area known as Jupiter Farms. This area has been subdivided and sold as residential tracts ranging in size from one to five acres. Drainage occurs through a series of seven east-west collector canals into Canal 14 (C-14), and a North-South canal administered by SIRWCD. The C-14 discharges directly into the Northwest Fork just South of the bridge at Indiantown Road.

The headwaters of the NW Fork of the Loxahatchee River, fed by C-14, is the primary source of flows to the Northwest Fork during most periods of the year (**Table 3**). On average, C-14 accounts for 40 percent of the total discharge to the Northwest Fork during the period 1980-1982. On a monthly basis, however, discharge from this source ranged from as low as 28 percent to as high as 72 percent of the total discharge.

In an attempt to restore historical flow between the Loxahatchee Slough and the Northwest Fork, flows may be diverted from SFWMD's C-18 (which drains the Slough) to the SIRWCD C-14 (which leads to the Northwest Fork). A SFWMD water control structure known as G-92 was constructed to recreate the connection severed by the construction of local drainage works. Originally a small culvert, this structure was enlarged to convey up to 130 cfs in 1975. In 1987 it was replaced by a gated control structure capable of passing up to 400 cfs in either direction. This structure is operated via remote telemetry from the SFWMD Operations Control Room under a joint agreement with the SIRWCD to permit conveyance of environmental flow to the Northwest Fork. It also functions to convey excess water from SIRWCD into the C-18 during extreme storm events.

Table 3. Average freshwater inflow into the Northwest Fork from major tributaries for selected rainfall periods (1980-1982).

Major Tributaries	1980 West Season May - Oct 1980		1980-81 Extended Dry Season Nov 1980 – July 1981		1981 Wet Season Aug – Sept 1981		1981 Tropical Storm Dennis August 1981		1982 Spring Storm Mar – Apr 1982	
	cfs	% Total	cfs	% Total	cfs	% Total	cfs	% Total	cfs	% Total
N.W. Fork – at Indiantown Road (C-14 canal)	65	44	28	49	106	35	242	29	236	45
N.W. Fork – Inflow between Indiantown Rd and Turnpike	17	12	3	5	32	10	198	24	44	9
Cypress Creek	45	31	20	35	132	43	265	32	190	36
Hobe Groves Canal	12	8	5	8	18	6	108	13	51	10
Kitching Creek	8	5	2	3	17	6	21	3	ND	ND
TOTAL INFLOW	147	100	58	100	305	100	834	100	521	100

Source: USGS Data (Russell and McPherson, 1984)

The operation schedule for G-92 is important to the river management program because of its role in determining water flow to the Northwest Fork. Water is discharged from C-18 through the diversion structure depending on the relationship between water levels in C-18 and the Northwest Fork at Indiantown Road. Water is diverted to C-14 when (a) flows in C-14 fall below 50 cfs; and (b) when levels in C-18 exceed 12.5 feet above sea level (normal canal stage is 14.5 feet). Under this operational schedule minimum flow discharges to the Northwest Fork have increased significantly since the operation of G-92 began. This is partially because of (a) higher rainfall amounts, (b) C-18 has been maintained at higher levels, and (c) water levels at Indiantown Road have been improved due to the reconstruction of Lainhart and Masten Dams, (two small weirs located about 0.1 mile and 1.2 miles respectively, downstream of Indiantown Road). Erosion of these weirs, along with canal construction in the basin, probably increased historic drainage in the area, thus contributing to increased discharges into the river and subsequent over-drainage and loss of base flow. Since C-18 has very little capacity to store water for a prolonged controlled discharge, supplemental discharges may be terminated during prolonged dry periods. While the installation of G-92 has significantly moderated the effects of drought conditions on water flow in the Northwest Fork, it has not completely achieved the goal of a “guaranteed” minimum flow of 50 cfs (a stage of 10.9 feet at the Lainhart dam) to preserve the freshwater character of the river. Restoration of more historic water levels in the Loxahatchee Slough, which could then sustain longer base flow discharges to the Northwest Fork

during drought, is the next step toward achieving this objective. In addition, Palm Beach County has acquired 10,389 acres within the Loxahatchee Slough as a component of the Palm Beach County's Environmentally Sensitive Lands Acquisition Program. A plan for hydrologic restoration of the Slough and flow enhancement to the Northwest Fork is currently being developed.

Cypress Creek is another significant source of surface water to the Northwest Fork, particularly during periods of low flows. This tributary enters the river from the west, just downstream from the Trapper Nelson Interpretive Site in JDSP. Discharges from Cypress Creek are normally less than those from the Loxahatchee River at Indiantown Road. During the period 1980-1982, Cypress Creek discharged an average of 35 percent of the total tributary discharge to the Northwest Fork.

Cypress Creek is an outlet for an extensive network of agricultural canals, draining an area of about 4,500 acres, maintained by the Hobe-St. Lucie Conservancy District. The first portion of the Cypress Creek subbasin, however, is composed of undeveloped wet prairie. These undeveloped areas are experiencing reductions in water levels due to canal construction, but still act as an important freshwater reservoir for Cypress Creek and the Northwest Fork. In 1995, Palm Beach County acquired 367 acres near Cypress Creek as part of their Environmentally Sensitive Lands program. This acquisition, and more importantly the Pal Mar wetlands acquisition, plus the concurrent modification of adjacent agricultural practices to improve on-site water management, will result in some improvements to the subbasin hydrology.

Hobe Groves Ditch (canal), which enters the river at approximately River Mile 9.0 and drains large agricultural areas east of the Florida Turnpike, averaged less than eight percent of the discharge to the Northwest Fork during the 1982 USGS study.

Kitching Creek, which originates in an area of scattered ponds and marshes both north of and within, JDSP, provided an average of 4 percent of the discharge during the 1982 USGS study. Its drainage basin is the least developed of all the major tributaries of the Northwest Fork and allows for a high degree of water retention. In addition to flows coming in from upstream via the C-14 canal, the segment of the NW Fork between Indiantown Road and the Florida Turnpike/I-95 receives an average of nearly 12 percent of its total flow from several small unnamed tributaries within this reach.

Water Quality

The following information was taken from the *Loxahatchee River Watershed Action Plan* (FDEP 1998). The basins discussed below are shown in **Figure 4**.

Subbasin 1 (Jonathan Dickinson/Hobe Sound)

The majority of the available information on water quality for Sub-basin 1 (Jonathan Dickinson/Hobe Sound) is on STORET, which is a continental storage and retrieval database currently managed by the United States Environmental Protection Agency (USEPA) in North

Carolina. Water quality within Sub-basin 1 is described as alkaline, tannin-colored water of good quality. The Park and the Loxahatchee River depend on surface water flow and the horizontal movement of water through the sandy soils from the surrounding areas. This movement aids the filtering of the stormwater runoff contaminants and helps to maintain the quality of water entering the Loxahatchee River.

Two long term monitoring stations have been sampled in Sub-basin 1, and several other locations have received attention in recent years. The first long term station is located in the North Fork of the Loxahatchee River at the southern border of the Park. The salinity ranges widely from a mean of 16 parts per thousand. The dissolved oxygen averages near 5 mg/l and biochemical oxygen demand is present in concentrations around 1.5 mg/l. Nutrients are relatively low, yet fecal coliform bacteria are present in moderate numbers. The water quality at this site is rated as fair according to the Florida Water Quality Index value of 52. The second long term sampling station is in Kitching Creek, approximately one-quarter mile upstream from its confluence with the Loxahatchee River. Water quality monitoring at this site has been infrequent and inconsistent, and the results have been variable.

Due to a lack of historical data, there has been heightened interest in the upper reaches of Kitching Creek, especially where Jenkins Canal enters the Park at its northern border, and in the upstream reach of the North Fork. In 1992, the Loxahatchee River District and the Florida Park Service initiated a joint program to conduct water quality studies along Kitching Creek and its associated wetland along the Park's western boundary. The results of these studies have not been formally compiled, however, the water in Jenkins Canal appears to be poor quality, while the surface water emanating from the Park appears to be good quality.

Biological integrity can be determined by monitoring the species of macroinvertebrates found within the bottom substrate. The Department of Environmental Protection (DEP) has been monitoring water quality and macroinvertebrates in the Park since 1992. The North Fork is one of only a few southeast Florida streams that qualify this area as a DEP "Biological Reference" site (DEP, 1997). The upstream portion of the North Fork has a low nutrient (oligotrophic) freshwater ecosystem, and is particularly vulnerable to the effects of nutrient loading.

Subbasin 2 (Coastal Areas)

Due largely to the influence of the Atlantic Ocean, the quality of the surface waters in Sub-basin 2 is quite good. Five long-term water quality monitoring stations (one in the inlet and two each in the Lake Worth Creek and Indian River Lagoon reaches of the ICW) have provided information for over 20 years. Salinity concentrations are typically above 30 parts per thousand, which indicates that the proportion of sea water is in excess of 80%. Water clarity on incoming tides is generally very good, and is characterized by low turbidity and color levels and by seechi disc readings exceeding 2 meters. The dissolved oxygen concentrations are almost always near 6.5 milligrams per liter and the biological integrity is high. Since the early 1970s, the average count of fecal coliform bacteria has consistently been below 30. The only qualitative characteristics that have changed significantly over the past twenty-five years are total nitrogen

and biochemical oxygen demand, each of which has increased well above the values recorded in the 1970 period.

Depending on the height of the groundwater table, groundwater may seep into surface waters through the porous sands. This groundwater seepage historically played a major role in the salinity levels within the entire lagoon. Contaminated groundwater seeping into surface water could have an adverse effect on water quality.

In summary, the waters of the Sub-basin 2 continue to exhibit good water quality, as expressed by the composite analysis of the Florida Water Quality Index.

Subbasin 3 (The Estuary)

Surface water quality within the estuary is quite variable, and is highly dependent on the mix of saltwater and freshwater. Sea water is saline, typically very clear, fairly high in dissolved oxygen, and low in nutrients and bacteria. Conversely, freshwater discharges to the estuary from inland sources typically have less clarity, are lower in dissolved oxygen content, and contain greater concentrations of nutrients and bacteria counts. Therefore, water quality varies at different points within the estuary. The water quality recorded on a high tide during the dry season can be quite different from the quality of water recorded on an outgoing tide during a high rainfall period.

Nine water quality stations located in the Sub-basin 3 have been monitored since the early 1970s. The information available from this data can be useful in presenting a composite picture of water quality. Salinity typically ranges from nearly 30 parts per thousand (ppt) on the eastern margin of the subbasin to below 15 ppt at the upper reaches of the three river forks within the basin. The clarity of water in the estuary is generally good, with turbidity averaging 3 milligrams per liter (mg/l), color around 50 and sechie disc measurements greater than 1.3 meters. Average dissolved oxygen concentrations are also good (6 mg/l or above). However, biochemical oxygen demand values tend to be increasing toward a watershed high of 2 mg/l. Levels of fecal coliform bacteria also have increased from the 1970 levels. Total nitrogen readings have nearly doubled to concentrations above 1.2 mg/l, and sometimes exceed 2 mg/l. The Florida Water Quality Index for a composite of the estuarine stations has fallen from a good rating recorded in the 1970s to a fair rating in recent years.

Subbasin 4 (C-18 Canal Basin and the Corbett Area)

The surface water in Sub-basin 4 is freshwater, found in lakes, canals, streams, and wetlands. The quality of the water in the northern portion of the C-18 compares very favorably to that in other freshwater tributaries that discharge into the Loxahatchee River estuary. The C-18 water quality similarly compares well to other freshwater areas throughout the state of Florida. The Florida Water Quality Index rated the quality very good in the 1970-1977 time period, and the Index has remained categorized as good (during the period 1978-1987). There has been no consistent trend upward or downward over the past 20 years.

The average turbidity for the entire period of record was 2.8 mg/l. Total suspended solids averaged 3.6 mg/l and normal color was near 60 standard units. Dissolved oxygen levels consistently were near the historic mean of 6.1 mg/l, which corresponds to an approximate 74% saturation rate. Biochemical oxygen demand (BOD) and chemical oxygen demand averaged 1.3 mg/l and 12.8 mg/l, respectively, with some increase observed in the BOD levels over the last 15 years. The abundance of nuisance aquatic plants in the C-18 can cause dissolved oxygen to decrease during extended periods of cloud cover.

Trophic status levels are good, with total nitrogen and total phosphorus present in average concentrations of 1.1 mg/l and 0.04 mg/l, respectively. Most fecal coliform bacteria counts were near 70 units, with only occasional readings exceeding 200 units. Alkalinity was normally between 110 and 140, and pH averaged 7.7. The mean temperature of 25.7 degrees C fluctuated seasonally between below 20 degrees C and over 30 degrees C.

There is an absence of data collected during times of discharge to the estuary (Sub-basin 3). It is commonly believed, and supported by some information, that the water quality degrades when velocities in the canal cause scouring of the bottom sediments and mixing during discharge events. Large volumes of water discharged to tide after major storm events result in very high nutrient and organic loadings entering the estuary.

Water quality information may be available from private sources for the southern portion of Sub-basin 4. This data was not available for evaluation at the time the action plan was drafted. It is not known if runoff from industrial or agriculture sites, or golf courses, are adversely affecting water quality in the developed portions of this subbasin.

Subbasin 5 (Cypress Creek/Pal-Mar)

From the water quality perspective, this subbasin can also be divided into two parts, the western portion consisting of relatively natural wetland communities (Pal-Mar) and the eastern portion lying between Pratt & Whitney Road and the Loxahatchee River (Cypress Creek). Although no water quality investigations have been documented in the Pal-Mar area, the water quality in this area is presumed to be representative of natural wetlands, and therefore, the water quality should be good.

The lands within the eastern portion of the subbasin are partially developed into residential neighborhoods, golf courses, and agricultural uses. These developed lands drain into Cypress Creek. A long term water quality monitoring station is located in Cypress Creek upstream of its juncture with the Northwest Fork of the Loxahatchee River. Water quality has been variable over the last 20 years, but on average, the color, total suspended solids, and nutrients are high in relation to other freshwater sites. Dissolved oxygen has been recorded at very low levels, but typically is above 5 milligrams per liter. The Florida Water Quality Index number for the Cypress Creek station is 48, in the fair range.

Subbasin 6 (The Groves)

Stormwater runoff is collected in ditches in the groves and in depressions in the natural areas. When holding capacity is reached in the ditches, water is discharged to the Northwest Fork of the Loxahatchee River. Water quality samples are collected monthly by the Hobe-St. Lucie Conservancy District from surface waters at intake and outfall points, and in the Northwest Fork. Samples are analyzed for temperature, pH, dissolved oxygen, biochemical oxygen demand, chloride, turbidity, total suspended solids, nitrates, and total phosphorous. This data was not available for review prior to the drafting of this action plan. The State Park staff and Loxahatchee River District personnel also collect water quality samples in Cypress Creek and Hobe Grove Canal. Currently none of these groups are analyzing samples for heavy metals or pesticides.

Water quality conditions within the Hobe Grove Canal upstream of its discharge into the Northwest Fork of the Loxahatchee River have been monitored at one long term station since 1982. On average, this station has exhibited higher total suspended solids, alkalinity, biochemical oxygen demand, nitrogen and phosphorous than is found in other freshwater tributaries to the Loxahatchee River. The Florida Water Quality Index for this canal is in the “fair” range (53), but inferior to the index number established for the Loxahatchee River near the confluence of Hobe Grove Canal.

According to the grove managers at Becker Groves and Sunrise Groves, best management practices (BMPs) are employed to conserve water and soil, and improve the quality of stormwater runoff. These BMPs include sodded beds to reduce soil erosion and integrated pest management. Irrigation water is stored in irrigation ditches and delivered to the individual citrus trees via microjet systems or low volume drip irrigation. Integrated pest management includes practices such as choosing plant varieties that are appropriate to the soil types and, therefore require less fertilizer and pesticides, and using alternative methods of pest control that reduce the use of pesticides. Culverts are installed one foot above the bottom of the irrigation ditches to increase sedimentation of suspended solids. Sunrise Groves maintains a weir on the Federation Canal that acts as a salinity barrier and increases sedimentation of suspended solids prior to discharge of water from the canal into Cypress Creek.

Subbasin 7 (Jupiter Farms/Wild and Scenic River)

Water quality in Sub-basin 7 can be considered in two parts, each of which exhibits very different water quality characteristics. The Wild and Scenic reach of the Loxahatchee River extends for approximately 7 miles from about three quarters of a mile south of Indiantown Road and ending after curving through Jonathan Dickinson State Park (Park). This reach of the river is sampled regularly by the Florida Department of Environmental Protection (DEP) and the Loxahatchee River Environmental Control District (LRD). Six long term water quality monitoring stations have been placed along this stretch of river and have been monitored since 1970. The Florida Water Quality Index for the first half of the period of record was ranked as only “fair” (averaged above 50). Turbidity, total suspended solids, were high, as were nutrients, especially total phosphorus. The trend for dissolved oxygen was down and fell below 4 milligrams per liter (mg/l), on several occasions. A significant change occurred in the mid 1980s

and is believed to have been associated with the increased introduction of water into the basin from the C-18 through a culvert known as the G-92. This renewed water source was superior in quality, averaging a Florida Water Quality Index of below 35 based on the results of long term water quality monitoring at a separate station in the C-18. When the C-18 water mixed with the river flows, it appears to have resulted in improved water quality. Over the last 15 years, the Florida Water Quality Index for the six river stations has been in the low 40s, a good water quality rating for the Wild and Scenic river.

The upper portions of the river can still experience problems, notably lowered dissolved oxygen. According to data collected by DEP as reported in the 1996 Ecosummary Report, “biological sampling indicates an extremely healthy aquatic invertebrate community. Average total phosphorous is currently about 0.06 mg/L, an acceptable level; however, there have been recorded spikes above 0.2 mg/l, particularly during 1984-86. Traces of the pesticide endosulfan were detected in sediment collected in 1993 by DEP. There was also a large copper-induced agrochemical fish kill in 1992. There is a downward trend in dissolved oxygen.” The mean dissolved oxygen level for 1994-95 was 3.8 mg/l, a violation of the 5 mg/l state standard. This same trend has also been reported by LRD water quality monitoring (River Keepers, Summer 1996). In 1995, a report entitled “*Dissolved Oxygen Concentrations and Relationships in Waters of the Loxahatchee River near Riverbend Park*” investigated the cause of lowered dissolved oxygen and identified the waters flowing from the canals of the Jupiter Farms area as a major factor. There have been recent investigations (LRD 1996, FDEP 1996) reviewing the rapid escalation of aquatic weed growth, the declining index of water quality, lowered dissolved oxygen, and a decrease in biological productivity. Although biological sampling of the macro-invertebrate community by the LRD and DEP indicates an extremely healthy environment, a downward decline in dissolved oxygen will cause adverse changes in this biological community.

The Jupiter Farms portion of this subbasin has also been monitored with two long term water quality stations and several shorter duration sampling points. Specific to the long term results, turbidity and nutrients are high and the presence of fecal coliform bacteria is increasing. Dissolved oxygen has been observed to fluctuate within a broad range both diurnally and seasonally. Florida Water Quality Index numbers near and above 50, the fair range, are typical.

In the Jupiter Farms portion of the subbasin SIRWCD has participated in a cooperative water quality monitoring program with the USGS from 1989 through 1998. In 1996 the USGS issued a report on the first five years (1989-1994) of this study. With two routine exceptions, the primary water quality standards are being met. Certain secondary water quality standards; (chloride, color, iron, and total dissolved solids) routinely are exceeded in samples collected in the LRD. Elevated levels of phosphorus exist in the surface waters of the LRD. Within the surface waters of the LRD, dissolved oxygen levels are often below the state standard of 4 mg/l for fish and wildlife. A significant portion of the time groundwater seeps into the canals, this groundwater inflow is low in dissolved oxygen. In addition, the warm climate encourages aquatic plant growth which increases the diurnal oxygen demand within the system, and warm water is less capable of storing dissolved oxygen.

Land Use

Much of the Loxahatchee River watershed remains undeveloped. Wetlands comprise a large portion of the river's upper watershed and total almost one-half of the drainage basin's 200 square miles. Urban areas and areas committed to urban uses make up one-quarter of the basin. The large agricultural and forested upland areas in the northern portion of the basin collectively comprise another one-quarter of the basin (**Figure 8**). **Tables 4 and 5** provide a detailed breakdown of the major land use categories (agricultural, range land, residential, industrial, commercial, undeveloped, transportation, conservation, institutional, and other) for each of the seven major drainage basins located within the watershed.

Table 4. Acreage percentage by land use for subbasins within the Loxahatchee River watershed

sb	Subbasin Name	Land Use Categories											
		Water	Agriculture	Range Land	Residential	Recreational	Industrial	Commercial	Undeveloped	Transportation	Conservation	Institutional	Other Urban
1	Jonathan Dickinson/ Hobe Sound		10.9%	4.8%	3.8%	1.6%	0.3%	0.0%	37.6%		41.0%		
2	Coastal		2.6%		30.4%	7.6%	2.3%	4.1%	50.2%	2.8%			
3	The Estuary	11.1%	4.8%		56.0%	5.5%	2.4%	1.2%	16.6%	1.8%		0.6%	
4	C-18/Corbett	2.4%	8.0%		3.5%	2.1%	3.8%	0.1%	78.0%	1.8%			
5	Cypress/Palmar	2.2%	12.1%		3.7%	1.2%			79.5%	0.2%			1.1%
6	The Groves	1.2%	59.5%		0.5%	0.5%			34.8%	3.0%			0.5%
7	Wild & Scenic/Jupiter Farms	2.1%	5.4%		56.8%	1.3%	3.3%	0.1%	29.8%	0.6%			0.6%

sb = Subbasin Number

Source: SFWMD 1995 GIS Land Use Database

Table 5. Acreage by landuse for subbasins within the Loxahatchee River watershed

		Land Use Categories												
		Water	Agriculture	Range Land	Residential	Recreational	Industrial	Commercial	Undeveloped	Transportation	Conservation	Institutional	Other Urban	Total Acres
sb	Subbasin Name													
1	Jonathan Dickinson/ Hobe Sound		2,509	1,105	875	368	69		8,656		9,439			23,021
2	Coastal		572		6,692	1,673	506	902	11,050	616				22,012
3	The Estuary	1,524	659		7,690	755	330	165	2,280	247		82		13,732
4	C-18/Corbett	1,540	5,132		2,245	1,347	2,438	64	50,039	1,155				64,153
5	Cypress/Palmar	652	3,587		1,097	356			23,569	59			326	29,647
6	The Groves	129	6,382		54	54			3,733	322			54	10,726
7	Wild & Scenic/Jupiter Farms	316	813		8,549	196	497	15	4,485	90			90	15,051
	Total	4,161	19,661						103,812					178,342

sb = Subbasin Number

Source: SFWMD 1995 GIS Land Use Database

Land in the river's watershed has most typically been converted to urban uses. The extreme southeastern section of the basin along the eastern edge of Loxahatchee Slough is one of the fastest developing areas in the basin. Another major area of land development is located in

the central portions of the basin, both east and west of C-18. Jupiter Farms, located west of the Loxahatchee River and south of Indiantown Road, is one example of the type of land development activity that has occurred in this portion of the basin. This 9,000-acre subdivision was platted in the 1920s and consists of parcels generally ranging in size from one to five acres.

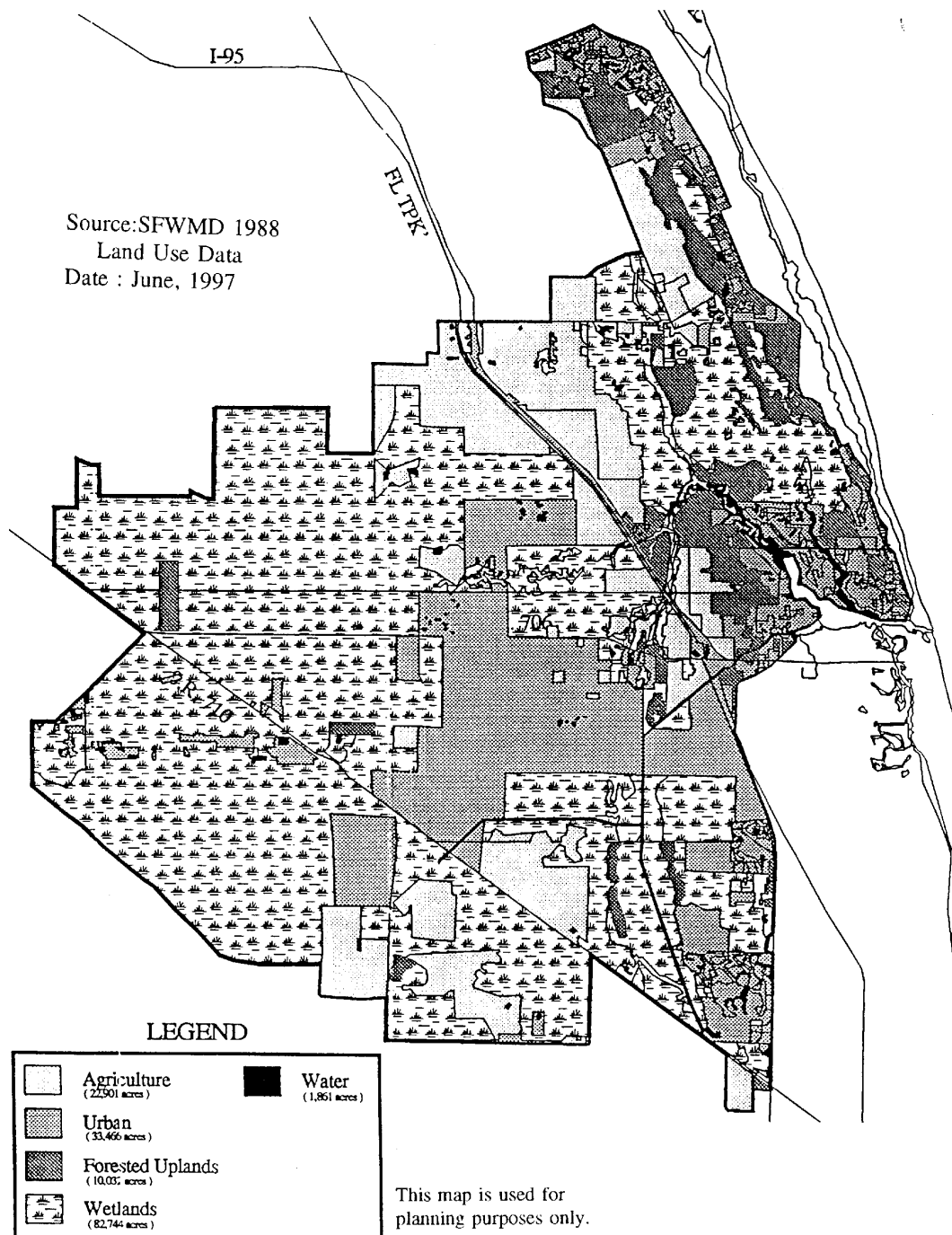


Figure 8. Current generalized land use/land cover in the Loxahatchee watershed (from FDEP/SFWMD, 2000)

When completed, the project will contain over 4,600 dwelling units and a population of more than 11,000 residents. Since the area was subdivided before current water quality regulations were in effect, the area does not have modern provisions for the retention of surface water runoff. A third area undergoing urbanization, and perhaps the one with the greatest potential for directly affecting the river, is the area north of Indiantown Road, bordered on the west, northwest, and east by the Northwest Fork. Existing land use activity is predominately agricultural, with most of the land in pasture or pine flatwoods. Major developments have been proposed, or approved, in this area.

Land use patterns in the immediate vicinity of the Northwest Fork are similar to those throughout the rest of the drainage basin. Wetlands are characterized primarily by extensive areas of pine and wet prairie, by the cypress swamp, and by mangroves. Agriculture accounts for approximately 23 percent of the land use in the vicinity of the Northwest Fork. Croplands, consisting mainly of truck farms, were until quite recently, located along either side of the middle segment of the river. In most cases, these areas are separated from the river corridor by a band of pine and scrubby flatwoods. Orchards and groves predominate in the northwestern sections of the river area. Several old small citrus groves are located in the Indiantown Road area within approximately 250 feet of the river. Improved pasture comprises a portion of the agricultural land cover east of the Florida Turnpike/I-95 highway corridors. Developed areas and areas that are committed to urban use are located throughout the eastern and southern portions of the mapped area, primarily south of JDSP and south of Indiantown Road. A small community shopping center is located 0.2 miles west of the river on Indiantown Road (FDEP and SFWMD 2000).

Water Supply

Public Water Supply Demands

Water for urban and agricultural uses in the Loxahatchee watershed is supplied from both groundwater and surface water systems. Non-environmental surface water demands within the basin are primarily public water supply, commercial and industrial with some agricultural uses. The commercial and industrial demands vary greatly by type of business. In the Loxahatchee Watershed commercial and industrial demands are less than one percent (1%) of the overall water demands. Because the demand is relatively small and difficult to generalize, an average demand is not calculated for this use category. The emphasis is placed on estimation of agricultural and urban uses. The 1995 withdrawals by the major public utility, industrial and commercial users are summarized in **Table 6**.

Total public water supply demands estimated for 1995 were 89,515 acre feet/year. Largest users within the watershed consisted of the City of West Palm Beach (28,248 ac-ft/year), Palm Beach County Utilities (20,934 ac-ft./year), SeaCoast Utilities (16,185 ac-ft/year), Town of Jupiter (10,629 ac-ft/year) and Riveria Beach (10,036 ac-ft/year). Together these five utilities represent 96% of the total urban water supply demand within the watershed.

Table 6. Urban water supply demands in the Loxahatchee Basin

Permittee	Permit Number	1995 Demands	
		Million Gallons/Year	Acre-feet/year
West Palm Beach	50-00615-W	9,205	28,248
Palm Beach Co.(2W,8W)	50-00135-W	6,822	20,934
Seacoast	50-00365-W	5,274	16,185
Town of Jupiter	50-00010-W	3,464	10,629
Riviera Beach	50-00460-W	3,270	10,036
Tequesta	50-00046-W	515	1,579
United Technologies	50-01663-W	212	650
PBC/Century Utilities	50-00178-W	153	470
Good Samaritan Hospital	50-00653-W	128	392
Mangonia Park	50-00030-W	124	381
PB Park Commerce	0-01528-W	4	11
Total		29,171	89,515

Source: SFWMD Unpublished Consumptive Use Permit Data

Agricultural Water Supply Demands

A different procedure was adopted for estimating agricultural use in the Loxahatchee watershed because measured withdrawal data were not available. The procedure used estimated current water use based on Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) water demand modeling (Smajstrla, 1990; Moraga et al. 1995), and current agricultural acreage (FDEP 1998). Agricultural water use depends on the crops that are grown in the watershed and on how those crops are managed and irrigated. An important factor in accurately estimating agricultural water use is determining the location and acreage of crops. Citrus and small vegetables are crop found in the basin. The supplemental irrigation requirements for 1995 are found in **Table 7**.

Table 7. Agricultural Demands for the Sub-Basins in the Loxahatchee River Basin.

Subbasin No.	Subbasin Name	1-in-2 Agriculture Demands (ac/ft)	1-in-10 Agriculture Demands (ac/ft)
1	Jonathan Dickinson/ Hobe Sound	3,032	5,123
2	Coastal	558	816
3	The Estuary	643	939
4	C-18/Corbett	6,201	10,478
5	Cypress/PalMar	4,335	7,324
6	The Groves	7,712	13,030
7	Wild & Scenic/Jupiter Farms	792	1,158
	Total	23,273	38,868

Sources: Smajstrla, 1990; Moraga et al. 1995; FDEP, 1998

Water Quality

Over the last two and one-half decades, the surface waters of the Jupiter Inlet - Loxahatchee River have been extensively sampled and analyzed for water quality. In the 1970's and 1980's, the United States Geological Survey provided a water quality monitoring presence from the

federal perspective. The FDEP and the SFWMD each sponsored monitoring programs from the state and regional perspective. On the county and local level, the Palm Beach County Health Department, Palm Beach County Department of Environmental Resources Management, and the Loxahatchee River District also monitored water quality. Since 1992, the Loxahatchee River District (LRD) has assumed responsibility for comprehensive monitoring in the watershed, monitoring 29 stations twice each month. In recent years, additional monitoring stations have been added.

In the early 1990's, the LRD, in cooperation with a technical advisory committee comprised of representatives of other monitoring efforts, organized the existing water quality data by collecting and screening all prior data. A common database was established, and the data presented in a format which could be indexed, composited, and compared to Florida State values and standards. The resultant information was further organized by dividing the Loxahatchee watershed into 29 sample locations in four ecological segments (Marine, Estuarine, Wild and Scenic, and Freshwater Tributaries). Five time-groupings covering 22 specific water quality parameters were developed. This summary was presented to the Loxahatchee River Management Coordinating Council in 1995.

Seven reaches or groups of stations have been monitored over the years within the Wild and Scenic portion of the Loxahatchee River. Additionally, six sampling sites are located in the freshwater tributaries flowing into the designated corridor. **Figure 9** shows the applicable water quality sampling sites.

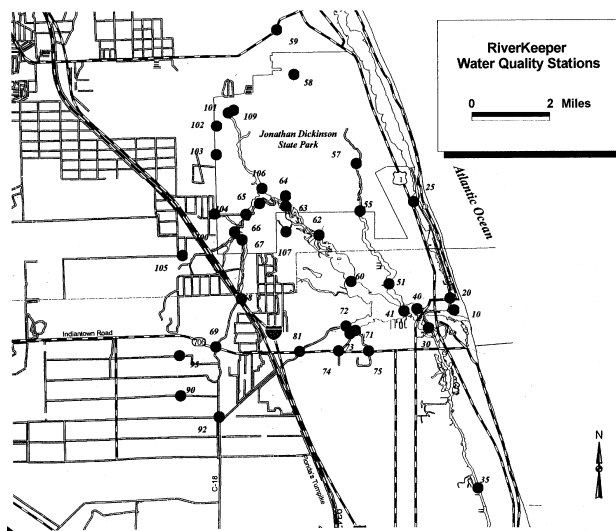


Figure 9. Water Quality Stations Sampled by the Loxahatchee River District

In general terms, the sampling results show that the water quality of the freshwater tributaries discharging to the wild and scenic corridor have remained fair for the period of record 1970-1993. The trend is for an overall decline in water quality in inflows over time. The wild and scenic river corridor also graded fair for the first portion of the monitoring period, then improved to good in the mid-1980's. The major reason for the improvement, and apparent

inconsistency with the declining quality of input waters, is believed to be the increased flows to the NW fork from the SFWMD C-18 canal. The quality of water in the C-18, a Class I waterbody, has rated superior to the other freshwater inputs and has not shown significant degradation over time.

Comparison of the long-term composite values for the Loxahatchee River Wild and Scenic corridor with typical Florida stream water quality values (as documented by FDEP) yields the following conclusions:

- Clarity of the river water is near the statewide mean
- The dissolved oxygen concentrations are low, ranking below about two-thirds of the other streams in Florida
- The organic content of the waters is moderately better than statewide averages
- The trophic status, predominantly nutrient concentration, is slightly better than values for other streams
- The biological integrity of the Wild and Scenic reach is on the low sides of the state mean, with six out of ten State streams displaying better results
- The bacteria counts are substantially higher than the state standard, ranking ahead of only about 30% of other streams
- The Florida Water Quality Index for several thousand Florida stream sampling sites averages 43.

The statewide WQ Index considers ratings of 45 or below as good, while ratings above 45 are considered fair. The 24-year average for the Wild and Scenic corridor is 48, however the index number for the period since 1985 has improved to 43. A station-to-station comparison of the river shows long-term water quality in each reach to display an index number near the mid-40's with three exceptions. The reach above Indiantown Road, and the reach near the Trapper Nelson Interpretive Site both have index numbers at, or above, 50. These numbers are in the fair range, but more closely approximate poor. Flows entering from the C-18 canal have a composite index number of 40, which is very good.

Natural Systems

Major Plant Communities

The principal wetland plant communities in the vicinity of the river corridor are freshwater cypress and saltwater-tolerant mangrove swamps (**Figure 10**).

Low pine flatwoods and scrubby flatwood communities occupy the slightly higher elevations bordering the floodplain. Other vegetation communities found in the area include sandhill, cypress dome swamp, hydric hammock, cypress strand swamp and wet prairie. The cypress swamp community solidly flanks the river and its tributaries upstream from the Trapper Nelson Interpretive Site, and is the dominant community for approximately one mile below the

site. This community is composed of bald cypress, southern red maple, cabbage palm, pop ash, pond apple, laurel oak and water hickory. Shrubby species mixed among the taller vegetation include cocoplum, wild coffee, myrsine, and buttonbush. Vines, ferns, bromeliads and orchids also are characteristic of this community.

The mangrove community lines the Northwest Fork from approximately one mile downstream of the Trapper Nelson Interpretive Site. Red mangroves front the river where they are most fully exposed to tidal flows. Some dead cypress trees tower above the red mangroves for approximately three quarters of a mile downstream from this point, evidence of the extent of freshwater vegetation that existed before changes in the upstream movement of salt water. White mangroves are somewhat removed from the river channel but near enough to be inundated at high tide.

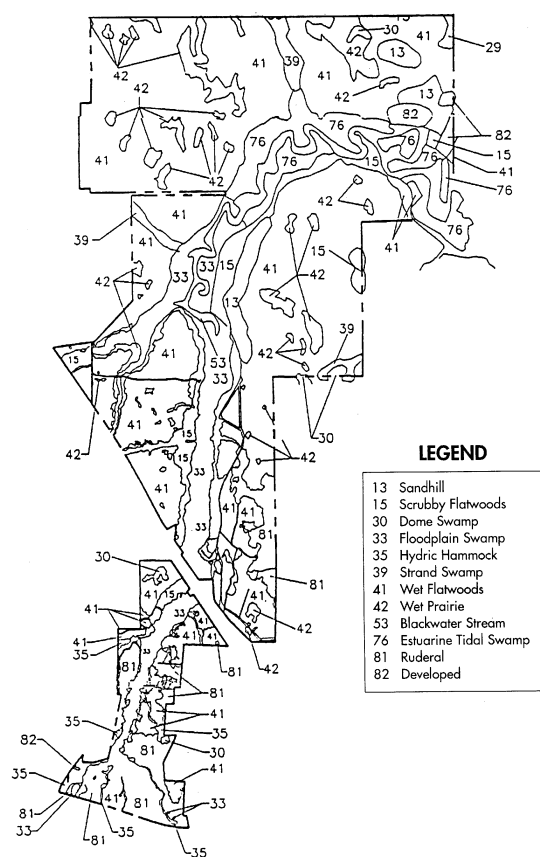


Figure 10. Wild and Scenic Corridor Plant Communities within Jonathon Dickinson State Park.
(Source: FDEP/SFWMD, 2000)

The low pine flatwood community is dominated by widely scattered South Florida slash pine. The slightly elevated, level sandy areas in which this plant community are found lack the soils and drainage conditions necessary to support the type of dense understory found in the floodplain. Vegetation is typically shrubby in nature, and includes the saw palmetto, gallberry and fetterbush. Ground cover includes wiregrass, broom sedge and various herbaceous species.

Scrubby flatwoods typically occupy the elevations above the pine flatwoods and alongside the floodplain. The sandy soil is usually several feet deep and drains rapidly even under extremely wet conditions. The dominant species is the South Florida slash pine, as in the pine flatwoods, but the understory is characterized by scrub oak and other scrub vegetation.

The principal problem affecting the river's plant communities is the gradual reduction in the number and geographic extent of healthy bald cypress in the floodplain and their replacement by mangroves. Virtually all of the cypress in the lowermost area of the Wild and Scenic river segment are now dead, or are stressed and not reproducing. Approximately one mile upstream of Kitching Creek, the number of live trees increases with increasing distance up the river. An analysis conducted by the U.S. Geological Survey between 1979 and 1982 documented the extent of environmental stress in the cypress trees along the Loxahatchee River corridor. The study examined core samples to identify changes in tree ring width and quality. The results of the study indicated that although all of the trees sampled had experienced stress at periodic intervals over their life histories, the proportion of stressed trees in the downstream section (below river mile 9.0) increased from 30 percent in 1940 to 80 percent in 1982. Stressed trees above river mile 9.0 decreased from 11 percent to 3 percent during the same period. Further, the study found a high correlation between the incidence of growth stress and high salinities in surface water and soils.

Based on this study, and the other available research, it is evident that the decline of cypress in the river is attributable to the upstream movement of salt water. Occasional inundation by saline surface water probably does not result in serious or long-term effects. Frequent inundation, however, gradually increases the salinity of the floodplain's peat soils. Since these soils are not readily flushed, the resulting stress gradually spreads to more and more trees. Attempts to identify the principal cause of saltwater intrusion, and to make precise correlations between stress periods and the dates of known events likely to have affected tree growth, have been inconclusive. Nonetheless, four contributing factors have been identified as follows: (1) permanent opening of the Jupiter Inlet in 1947, (2) insufficient flows to the Northwest Fork; (3) dredging in the river's estuary and in Jupiter Inlet; and (4) the drawdown of groundwater levels by wells in the Jupiter-Tequesta area. Each of these factors must be addressed if deterioration of the river's cypress communities is to be reversed.

Wetlands

The Loxahatchee River Basin Wetland Planning Project (Treasure Coast Regional Planning Council, 1999) was initiated in 1994 to identify wetlands in the Loxahatchee River Basin and provide information about the functions and values of these wetlands. The major wetland systems in the Loxahatchee River basin are listed in **Table 8**. Interpretation of the infrared aerial photographs resulted in the identification of areas of high, medium and low quality wetlands. Seventy-nine percent of the wetlands in the project area are located in areas of high quality wetlands, 13% in areas of medium quality wetlands, and 8% in areas of low quality wetlands. The largest area of high quality wetlands is the Loxahatchee Slough. The second largest area of high quality wetlands is Pal-Mar. Other locations identified as areas of high quality wetlands include Corbett WMA, the Cypress Creek Area, the Loxahatchee River SOR

property north of Indiantown Road, large preserve areas on the North Palm Beach County General Aviation Airport and PGA National, and a portion of Vavrus Ranch.

Table 8. Major wetland systems in the Loxahatchee River watershed

Wetland System	Area	County	Location	Ecosystems	Hydrology
Atlantic Coastal Ridge	12,700 ac.	Eastern Martin	Between I-95 and U.S. Hwy 1	Extensive upland and wetland systems, including wet flatwoods, marshes, forested sloughs and coastal scrub	Includes the headwaters of the South Fork of the St. Lucie River, North Fork of the Loxahatchee River and Kitching Creek
Cypress Creek	4.5 sq. mi.	Martin & Palm Beach	North of Indiantown Rd., west of the Northwest Fork	Forested and interspersed with marshes, cypress swamps, and wet prairies	Forms the headwaters of Cypress Creek
Jonathan Dickinson State Park	11, 500 ac.	S.E. Martin	The Park surrounds Kitching Creek, and portions of Cypress Creek, the Northwest Fork, and the North Fork of the Loxahatchee River	Extensive wet pine flatwoods, marshes, wet prairies, and forested swamps	Surrounds Kitching Creek and portions of Cypress Creek, the Northwest Fork, and North Fork of the Loxahatchee River
J.W. Corbett Wildlife Management Area	57, 000 ac.	Northern Palm Beach	Adjacent to DuPuis Reserve	Wet flatwoods, mesic flatwoods, wet prairies, marshes, cypress swamps, and remnants of the Everglades	The Hungryland Slough begins in Corbett and flows east until it meets the Loxahatchee Slough
Hungryland Slough	>10,000 ac ¹	Palm Beach	Northwestern portion of the Loxahatchee Slough Natural Area	Pine flatwoods, wet flatwoods, cypress swamps, depression marshes, and wet prairies	A remnant slough; formerly flowed from the area near Corbett WMA to merge with the northern portion of the Loxahatchee Slough; drained by the west leg of the C-18 canal; drainage is to the east toward the Loxahatchee Slough
Loxahatchee River Preserve Area	1, 926 ac.	Southern Martin & Northern Palm Beach	Adjacent to Jonathan Dickinson State Park and Palm Beach County's Riverbend Park	River floodplain	Surrounds the Loxahatchee River and includes a portion of the historic floodplain of the Northwest Fork
Loxahatchee Slough	>13, 000 ac.	Palm Beach	West of the Turnpike and north of SR 710	Wet flatwoods, marshes, cypress swamps, wet prairies, and hydric hammock	The Loxahatchee Slough flows north from the West Palm Beach Water Catchment Area toward the Northwest Fork of the Loxahatchee River; Drained by the east leg of the C-18 canal
Pal-Mar	37, 000 ac.	Southern Martin & Northern Palm Beach	East of Beeline Hwy., north of Indiantown Rd. and west of SR 711	Pine flatwoods, marshes, and wet prairies	Hydrology is nearly unaltered, ditches and canals are present but have not caused significant impact to the historic flow of water
South Fork of the St. Lucie River	184 ac.	NW Martin	Adjacent to the Atlantic Coastal Ridge	Riverine system	Surrounds the lower reaches of the river
West Palm Beach Water Catchment Area	19.3 sq. mi.	Palm Beach	Impounded portion of the Loxahatchee Slough located south of SR 710	Pine flatwoods, hydric pine flatwoods, hardwood hammocks, marsh and cypress heads and cypress-shrub	Limited connection to the Loxahatchee Slough via two culverts under the Beeline Highway; Historic headwaters of the Northwest Fork of the Loxahatchee River

Treasure Coast Regional Planning Council, 1999; Martin County Planning Dept., 2000; ¹ SFWMD SOR Program Staff

The largest areas of medium quality wetlands occur in Unit 11 of the Acreage, the Sandhill Crane Addition to the Loxahatchee Slough Natural Area, portions of the Vavrus Ranch, and Loxahatchee River SOR property south of Indiantown Road. Other locations identified as areas of medium quality wetlands are the preserve areas on sites that have been developed during the last 20 years. These include Old Marsh Golf Club, Palm Beach Park of Commerce, and the smaller preserve areas on PGA National and the North Palm Beach County General Aviation Airport. In addition, portions of two sites currently proposed for development, the Golf Digest and Country Lakes of Jupiter sites are identified as areas of medium quality wetlands. The main areas of low quality wetlands include Jupiter Farms, Palm Beach Country Estates, Caloosa, and the Acreage south of Mecca Farms. A portion near the center of Vavrus Ranch is also identified as an area of low quality wetlands.

Twenty-four percent of the wetlands in the watershed are freshwater marsh and wet prairie, hardwood swamp, and cypress swamp. The main concentrations of freshwater marsh and wet prairie are located in and near the Loxahatchee Slough, Corbett WMA and Pal-Mar. The largest concentration of hardwood swamp occurs along the Loxahatchee River. The main concentrations of cypress swamps occur in and just east of the Cypress Creek area north of Indiantown Road, and in and adjacent to the Loxahatchee Slough, especially near the Beeline Highway. A large stand of cypress also occurs in Corbett WMA just south of Pratt & Whitney. (Treasure Coast Regional Planning Council, 1999).

Uplands

According to the 1984 National Wetlands Inventory, 61.3% of the Loxahatchee River watershed is uplands. Upland communities present in the Loxahatchee River watershed are sandhill, pine flatwoods, hydric pine flatwoods, sand pine scrub, xeric oak scrub, beach and dune systems. (Treasure Coast Regional Planning Council, 1999) The watershed contains some of the last remaining coastal sand pine scrub communities on Florida's southeast coast (FDEP, 1998)

Estuary

The estuary is centrally located within the Loxahatchee River watershed (**Figure 2**) and receives freshwater from three major tributaries of the Loxahatchee River and sea water from the Jupiter Inlet. The mixing of sea water and freshwater creates the brackish water characteristic of the estuary. The central embayment is shallow with an average depth of four feet and the area is 0.6 square miles (FDEP, 1998; Antonini et. al., 1998).

Natural communities in the estuary are seagrass beds, tidal flats and oyster beds. The tidal and freshwater flows determine bottom sediment characteristics and sustain several distinct biological communities. Seagrass beds and oyster bars grow where suitable undisturbed bottom sediment occurs and where tides maintain adequate salinity and flow conditions (FDEP, 1998). Seagrass covers approximately 5 percent of the water area; it is found fringing the shoreline; as extensive beds southwest of the sandbar and in shoal water at the mouth of the North Fork, and as patches between Dolphin and Marlin canals and between the mangrove islands and the Alternate A1A bridge. (Antonini, et al, 1998)

Fauna and Flora

The combination of climate, vegetation, and water bodies in the Loxahatchee River area has resulted in a high diversity of animal species. In 1965, two hundred sixty-seven species, consisting of 169 genera and 78 families were observed in and along the river and its estuary. The area surrounding the Northwest Fork is inhabited by numerous vertebrate species identified as endangered, threatened or of special concern by the Game and Fresh Water Fish Commission, or listed as threatened or endangered by the U.S. Fish and Wildlife Service (**Table 9**)..

Table 9. Threatened and endangered animals in the Loxahatchee River watershed

Scientific Name	Common Name	FCREPA ¹	FGFWFC ²	USFWS ³
Fish				
<i>Centropomus undecimalis</i>	Common snook		SSC	
Amphibians				
<i>Rana capito aesopus</i>	Gopher frog	T	SSC	
Reptiles				
<i>Alligator mississippiensis</i>	American alligator	SSC	SSC	T(S/A)
<i>Drymarchon corais couperi</i>	Eastern indigo snake	SSC	T	T
<i>Gopherus polyphemus</i>	Gopher tortoise	T	SSC	
<i>Pituophis melanoleucus</i>	Florida pine snake		SSC	
Birds				
<i>Ajaia ajaja</i>	Roseate spoonbill	R	SSC	
<i>Aphelocoma coerulescens</i>	Florida scrub jay	T	T	T
<i>Aramus guarauna</i>	Limpkin	SSC	SSC	
<i>Dendroica kirtlandii</i>	Kirtland's warbler	E	E	E
<i>Egretta caerulea</i>	Little blue heron	SSC	SSC	
<i>Egretta thula</i>	Snowy egret	SSC	SSC	
<i>Egretta tricolor</i>	Tricolored heron	SSC	SSC	
<i>Eudocimus albus</i>	White ibis	SSC	SSC	
<i>Falco peregrinus tundrius</i>	Arctic peregrine falcon	E	E	
<i>Falco sparverius paulus</i>	Southeastern American kestrel	T	T	
<i>Grus canadensis pratensis</i>	Florida sandhill crane	T	T	
<i>Haliaeetus leucocephalus</i>	Bald eagle	T	T	T
<i>Mycteria americana</i>	Wood stork	E	E	E
<i>Picoides borealis</i>	Red-cockaded woodpecker	E	T	E
<i>Rostrhamus sociabilis</i>	Snail kite	E	E	E
<i>Speotyto cunicularia floridana</i>	Florida burrowing owl	SSC	SSC	
<i>Sterna antillarum</i>	Least tern	T	T	
Mammals				
<i>Blarina carolinensis shermani</i>	Sherman's short-tailed shrew	SU	SSC	
<i>Peromyscus floridanus</i>	Florida mouse	T	SSC	
<i>Sciurus niger shermanii</i>	Sherman's fox squirrel	T	SSC	
<i>Trichechus manatus latirostris</i>	West Indian manatee	T	E	E

Treasure Coast Regional Planning Council, 1999 ¹ Florida Committee on Rare and Endangered Plants and Animals

² Florida Game and Fresh Water Fish Commission; ³ Florida Game and Fresh Water Fish Commission

E = Endangered; R - Rare/ T = Threatened/ T(S/A) = Threatened/Similarity of Appearance; SSC = Species of Special Concern/ SU = Status Undetermined

In addition, the entire Loxahatchee River has been designated by the U.S. Fish and Wildlife Service as a critical habitat for the West Indian manatee. Invertebrate and vertebrate aquatic animals are numerous in the marshes, lakes and streams in the river area. Freshwater fish include largemouth bass, speckled perch, bluegill, shellcracker, redbreast, warmouth, bowfin, gar, channel catfish and many species of minnows. The manatee, an endangered aquatic mammal, frequents the Loxahatchee River estuary. Numerous turtles also live in and around the river. Saltwater fish include snook, tarpon, mullet, bluefish, jack, sheepshead, drum, sand perch, grouper, snapper and flounder. Mammals and birds are frequently encountered along the

riverbank. The more commonly seen species include raccoon, opossum, whitetail deer, osprey, barred owl, egrets, herons and ibis.

Additional species, although not identified on the official lists compiled by the State of Florida, may be identified as being either endangered, threatened or of special concern by the Florida Committee on Rare and Endangered Plants and Animals.). The state listed listed plants are shown in **Table 10**.

Table 10. Threatened and endangered wetland plant species that occur in the project area.

Scientific Name	Common Name	Designated Status ¹	
		FCREPA ²	FDACS ³
<i>Acrostichum danaeifolium</i>	giant leather fern		C
<i>Bletia purpurea</i>	pine pink		T
<i>Calopogon barbatus</i>	bearded grass pink		T
<i>Calopogon multiflorus</i>	many-flowered grass pink		E
<i>Campyloneurum phyllitidis</i>	long strap fern		E
<i>Chrysophyllum ofiviforme</i>	Satinleaf		E
<i>Dennstaedtia bipinnata</i>	cuplet fern	E	E
<i>Drosera intermedia</i>	water sundew		T
<i>Encyclia tampensis</i>	butterfly orchid		C
<i>Eulophia alta</i>	wild coco		T
<i>Hexalectris spicata</i>	crested coralroot		E
<i>Lilium catesbaei</i>	Catesby's lily		T
<i>Lycopodium cernuum</i>	nodding club moss		C
<i>Nemastylis floridana</i>	celestial lilt	T	E
<i>Nephrolepis biserrata</i>	giant sword fern		T
<i>Ophioglossum palmatum</i>	hand adder's tongue fern	E	E
<i>Osmunda cinnamomea</i>	cinnamon Fern		C
<i>Osmunda regalis</i>	royal fern		C
<i>Pecluma ptilodon</i>	swamp plume polypody		E
<i>Peperomia humilis</i>	pepper (unnamed)		E
<i>Pinguicula caerulea</i>	blue-flowered butterwort		T
<i>Platanthera nivea</i>	snowy orchid		I
<i>Pogonia ophioglossoides</i>	rose pogonia		T
<i>Spiranthes laciniata</i>	lace-lip ladies' tresses		T
<i>Spiranthes longilabris</i>	long-lip ladies' tresses		T
<i>Spiranthes vernalis</i>	ladies' tresses		T
<i>Stenorrhynchos lanceolata</i>	leafless red beak orchid		T
<i>Thelypteris serrata</i>	dentate lattice vein fern		E
<i>Tillandsia balbisiana</i>	inflated wild pine		T
<i>Tillandsia fasciculata</i>	common wild pine		E
<i>Tillandsia flexuosa</i>	twisted air plant	T	E
<i>Tillandsia utriculata</i>	giant wild pine		E
<i>Tillandsia valenzuelana</i>	soft-leaved wild pine		T

The list is a subset of the official lists of species prepared by the Florida Game and Fresh Water Fish Commission (Wood 1996). Species classified by the Florida Council on Rare and Endangered Plants and Animals are also included in this list. Refer to Ward (1979) for more information on listed plant species.

¹E = Endangered; R = Rare; T = Threatened; SSC = Species of Special Concern; C = Commercially Exploited

²Florida Committee on Rare and Endangered Plants and Animals; ³Florida Department of Agriculture and Consumer Services

The Loxahatchee National Wild and Scenic River and Jonathan Dickinson State Park contain 52 federal and state species that are endangered, threatened, or of special concern (23 animals and 29 plants). Those species having a federal designation found within this area are: the alligator, indigo snake, scrub jay, bald eagle, wood stork, snail kite, manatee, four-petal paw paw, perforate lichen and Small's milkwort (FDEP, 1998). The threatened osprey nests in dead cypress trees in the lower Northwest Fork. The great egret, the black-crowned night heron and the yellow-crowned night heron, classified as Species of Special Concern, are also found in the Loxahatchee River area.

Navigation and Recreation

Use of the Loxahatchee River and Estuary by motorized crafts is essentially limited by channel depth, width, and vertical clearance of bridges. Boats much larger than 25 to 30 feet are limited to the lower portions of the river by both lack of depth and vertical clearance (Law Environmental, 1990). The estuary central embayment is a shallow water region. Over 50 percent of this area is less than 2 ft. deep. The main river channel is the only improved access channel in the Central Embayment. (Antonini, *et al.*, 1998).

The reaches of the Loxahatchee included in the Wild and Scenic corridor have relatively limited public access points to the river. Existing access and major facilities that support public use are clustered at each end of the 7.5 mile Wild and Scenic segment, concentrating public use in these areas. Most existing river related recreational uses and major facilities occur within Jonathan Dickinson State Park (JDSP), but in the future other major facilities will be provided and managed by Palm Beach County at Riverbend County Park.

Riverbend County Park, (RCP) which includes the SFWMD's Reese and Gildan tracts, and JDSP are the two primary public access areas on the river RCP, located between Indiantown Road and the C-18 canal, comprises more than 600 acres and encompasses the half mile 'Recreational' segment of the river corridor.

Public access to the river at the downstream end of the Wild and Scenic corridor is available at two points. Both are JDSP boat docks. The first is the primary launching and take-out point for canoeists who rent boats from the park concessionaire. It is also the staging area for river cruises on the 44-foot "Loxahatchee Queen II", operated by the JDSP concessionaire. Restrooms, trails, cabins, and picnicking facilities are nearby. The other facility is located 0.5 miles downriver and consists of a concrete boat dock and ramp. It is adjacent to a developed JDSP campground. This site is used primarily by park visitors who bring their own boats and canoes, but is also used as the take-out point by canoeists completing the trip downstream from RCP. Several secondary access, or resting, points exist in the river corridor area, but these are relatively insignificant as contributing sources of use pressure.

The Loxahatchee's natural features and its proximity to the urban areas of Southeast Florida make it exceptionally well suited to provide outdoor recreation. Historically, canoeing has been the main recreational use of the river and its surrounding area, but other activities include kayaking, fishing, nature study, wildlife observation, and motor boating. Motor boating is effectively restricted to the portion of the river downstream from the Trapper Nelson Interpretive Site because of the narrow channel, numerous obstructions, and shallow depth of the upper river. Virtually all public recreational use of the upper river involves paddling, either as the primary activity or as a means of gaining access to the river area to enjoy other activities.

An important function of the river management program is to determine and monitor the quantity and mixture of recreation and other public use which can utilize the river without adverse impacts on its resource values. The recreation "carrying capacity" of rivers has received the attention of river managers for more than a decade, but there is little consensus as to the most

appropriate means for estimating carrying capacity. This is because carrying capacity is a dynamic concept and a number of factors exist, including management objectives, the physical and biological nature of the resource, and the preferences and tolerances of users, which must be considered together in determining a river's carrying capacity (FDEP/SFWMD, 2000)

WATER RESOURCE ISSUES -- PROBLEMS IDENTIFIED

The following information was taken from the *Loxahatchee River Watershed Action Plan* (FDEP 1998).

Surface Water Resources

Altered Hydroperiod. In response to flooding, drainage ditches and canals have been built to drain developed areas. Canals divert water and affect the historical flow patterns to natural wetland systems. Barriers have been built in many areas that interfere with the historical movement of water in this region. These impediments, including canals and roads, intensify flooding in some areas. This network of canals and barriers has reduced water storage in natural areas, caused flooding in other areas, and degraded water quality in surface waters.

Water Quality. Most of the upper watershed has not experienced major water quality problems. Some problems have been noted in the lower watershed, including decreasing dissolved oxygen in the “Wild & Scenic” Northwest Fork of the Loxahatchee River, and nutrient loading in the estuary.

Lack of Surface Water Quality Data. There is a lack of historical surface water quality data in some parts of the watershed, including the North Fork, Cypress Creek, and other tributaries of the Loxahatchee River.

Stormwater Runoff. Stormwater runoff introduces contaminants from developed areas into surface water. Contaminants include pesticides, nutrients, oils and grease, and suspended solids. These contaminants can reduce dissolved oxygen which can cause fish kills. The watershed has several older neighborhoods that were developed without adequate stormwater systems. This can cause flooding during heavy rainfall.

Salt Water Intrusion. Reduced flow in the Northwest Fork of the Loxahatchee River has allowed salt water to migrate upriver causing the introduction of mangroves into areas once dominated by cypress swamp.

Scouring/Siltation. During heavy rain events, tremendous flows cause scouring in residential and agricultural canals which increases sediment loading into surface waters. This phenomenon causes sedimentation in the navigable channels and has an adverse effect on the aquatic plants and animals.

Groundwater Resources

Wellfield Pumping. Over pumping groundwater has the potential to cause wetland drawdown impacts and saltwater intrusion into the freshwater aquifer. Under SFWMD rules utilities are not allowed to over pump the groundwater within the Loxahatchee

Groundwater Contamination. With the exception of the West Palm Beach Catchment Area, the majority of drinking water within the watershed is derived from groundwater. The most common source of groundwater contamination is leaking fuel storage tanks. Other contamination sources include dry cleaners, pesticide storage areas, and other operations that handle hazardous materials. With the exception of Sub-basin 6, there are known groundwater contaminated sites in all the of the other subbasins.

Wastewater Treatment. Nutrients leaching from septic tank drainage fields may seep into groundwater, which ultimately feeds surface waters. In some areas this can have a negative impact on water quality. Human sewage waste entering surface water poses a health threat to swimmers and other recreational users.

Habitat Management

Sustainable Usage - Recreation and Fisheries. With more and more people moving into the area, there is increased pressure on natural resources and more competition for limited recreational resources. Increased fishing puts more pressure on fish stocks. Seagrass beds are damaged by boat propellers in shallow areas. Fishing may not be compatible with competing activities such as water skiing and jet skis. The “Wild and Scenic” Northwest Fork of the Loxahatchee River is a popular destination for canoers and kayakers. Increased boat traffic has caused concern that the river’s carrying capacity will be exceeded.

Exotic Pest Plants. Exotic pest plant species have been introduced into Florida for decorative landscaping, agriculture, and to dry up wetlands for development. The introduction of these plants, whether accidental or intentional, has taken a toll on our remaining natural terrestrial and aquatic systems. The ability of these exotic species to reproduce rapidly, due to a lack of predatory pressure, allows them to spread quickly into natural ecosystems. Exotic species crowd out native species that would otherwise provide habitat shelter and food for native wildlife. Invasive exotic plants species reduce species diversity, impact endangered plants and animals, effect fire intensity, change evapotranspiration rates, and provide little or no benefit to the environment. There are many species of exotic plants within the watershed. The exotic pest plants of most concern in the watershed are Old World climbing fern (*Lygodium microphyllum*), melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthefolius*), Australian pine (*Casuarina spp.*), and downy rose-myrtle (*Rhodomyrtus tomentosa*). There are several exotic aquatic plants found in natural waterways and canals that impede navigation and cause water quality and habitat problems. Millions of dollars are spent annually by local, state, and federal agencies to eradicate exotic pest plants in Florida.

Exotic Animals. Exotic animals, like plants, are those species not native to Florida, but have been introduced as a result of human-related activities. Exotic animals upset the natural balance of ecosystems. They normally have fewer natural enemies and may have a higher survival rate than native species. Exotic animals displace native species by preying on them and/or out-competing them for food, shelter and habitat requirements. Some examples of exotic animals in the Loxahatchee River watershed include feral hogs, armadillos and the black acara.

Fire Management. Fire-dependent plant communities, including pine flatwoods and sand pine scrub, are found throughout the watershed. Due to the proximity of residential neighborhoods to these natural areas, naturally occurring fires from lightning strikes must be controlled to protect property. Land managers implement prescribed burn plans to provide the necessary fire cycle to renew these habitats. Prescribed fire management plans identify optimum wind conditions for conducting controlled burns, so that the smoke will not bother local residents. As more residential homes are constructed adjacent to natural areas, smoke management will become more difficult. The absence of fire management on privately owned land with fire-dependent plant communities presents problems for the implementation of necessary land management practices on publicly-owned land.

Habitat Fragmentation and Habitat Loss. Altered hydroperiod, development, exotic plant invasions, and lack of land management have contributed to wildlife habitat loss and fragmentation.

Off-Road Vehicle Damage to Habitat. Privately owned, undeveloped parcels are being accessed by users of off-road vehicles. The use of these vehicles on undeveloped land damages the native plant understory. Exotic pest plants often invade these disturbed areas.

Solid Waste Dumping. Dumpers use isolated roads in low density residential developments to avoid paying tipping fees at the landfill or costly hazardous waste disposal fees. Hazardous constituents from waste piles can leach into the environment, and also pose physical hazards to wildlife and humans. Waste tire piles, for example, provide breeding habitat for mosquitoes. The cost of cleaning up illegally dumped waste falls on the property owner if the dumper is not identified and forced to pay.

Urban Sprawl: Sprawl is defined as housing areas that are isolated or poorly connected to existing neighborhoods. The impacts of urban sprawl on natural resources can be direct (e.g., loss of habitat), or indirect (e.g., alteration of the water table in nearby wetlands).

Loxahatchee River Watershed Problem Matrix

The following matrix (**Table 11**) indicates which problems are found in which subbasins. Some problems are found throughout the watershed including altered hydroperiod and exotic pest plants. Other problems are isolated and affect only one or two subbasins such as beach erosion and off road vehicle damage. Part II of this action plan proposes projects to address many of the problems identified in the watershed subbasins.

Table 11. Problems identified within the various subbasins of the Loxahatchee River Watershed

Current Problems	Subbasin 1 Jonathan Dickinson/ Hobe Sound	Subbasin 2 Coastal	Subbasin 3 Estuary	Subbasin 4 C-18/ Corbett	Subbasin 5 Cypress/ Pal-Mar	Subbasin 6 Citrus	Subbasin 7 Wild & Scenic
Altered Hydroperiod	X	X	X	X	X	X	X
Water Quality			X				X
Lack of Water Quality Data	X			X	X	X	X
Stormwater Runoff	X	X	X			X	X
Saltwater Intrusion							X
Scouring/Siltation			X		X		X
Wellfield Pumping	X						
Groundwater Contamination	X	X	X	X	X		X
Wastewater Treatment	X	X	X				X
Sustainable Usage		X	X				X
Exotic Pest Plants	X	X	X	X	X	X	X
Exotic Animals	X			X	X	X	
Fire Management	X	X		X	X	X	
Habitat Fragmentation	X	X	X	X	X	X	X
Off Road Vehicle Impacts				X	X		
Solid Waste Dumping			X	X	X		X
Urban Sprawl	X			X	X		X